Greensboro Airport Area Modeling Study

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Prepared for the

Greensboro Urban Area

Metropolitan Planning Organization

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Table of Contents

1 Executive Summary

1.1 Purpose

The purpose of the analysis is to revaluate the projects in the Piedmont Triad International Airport (PTIA) area. There are currently multiple combinations of twelve separate projects that could be constructed in the PTIA area. The technical evaluation of cumulative conditions in the PTIA area will support Greensboro Urban Area Metropolitan Planning Organization (GUAMPO) transportation system planning decisions. It will ensure that all previously identified project needs still exist and that the various proposed roadways in the area will meet these needs.

1.2 Project Scenario Analysis

The projects under consideration in the PTIA area were evaluated with the following travel demand model data and cost information:

- Projects – Number of individual projects included in each scenario, ranging from one to twelve.
- Cost (Million) – Total cost of the projects included in each scenario, in millions of dollars.
- VHD (Vehicle Hours of Delay) Reduction – Difference in VHD between each scenario and the base scenario (2035 E+C network, no scenario projects).
- VHD Reduction/Project – Total VHD reduction per number of projects included in each scenario.
- VHD Reduction/Cost (Million) – Total VHD reduction per scenario cost.

The above data was used to develop three implementation plan strategies for constructing the twelve projects.

1.3 Preferred Implementation Plan Strategy

As shown in Table 8, this implementation plan focuses on building projects in order of greatest incremental VHD reduction/cost, or the most effective projects per dollar spent. This strategy calls for the construction of local roadways before new freeway projects. This strategy is favorable from a VHD reduction/cost standpoint, because it produces a 1,250 VHD reduction (roughly 22% of the maximum) with the construction of the fifth project, for a cost of only $151.2 million. This strategy backloads the costs and requires an increment of $444.1 million between the tenth and eleventh projects. It should be noted that the "maximize VHD reduction/cost" strategy project sequence is very similar to the "minimize cost" strategy.

Table 1. Maximize VHD Reduction/Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pegg/Thatcher Street Connection	553	$ 23.4	23.6
3	Pleasant Ridge Road Widening	673	$ 36.7	18.3
4	Bryan Boulevard Loop	899	$ 74.4	12.1
5	I-73 Connector	1,250	$ 151.2	8.3
6	Pleasant Ridge Road Relocation	1,328	$ 166.1	8.0
7	Airport Connector	1,328	$ 189.2	7.0
8	I-40 Connector	2,209	$ 235.6	9.4
9	Sandy Ridge Road Extension (North)	2,299	$ 258.4	8.9
10	I-73/I-74 Connector (Arterial)	4,440	$ 573.2	7.7
11	NC 68 Widening	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

1.4 Comparison of Strategies

Ultimately, the balance of VHD reduction and cost performance is a very reasonable strategy, and if pursued would be defendable from a cost standpoint, while also resulting in traffic improvements in the PTIA area. Additionally, the "maximize VHD reduction/cost" strategy is best for minimizing future risk. While all three strategies have similar VHD reduction at the end of the implementation plan (if all twelve projects are constructed and is considered a complete system), the "maximize VHD reduction/cost" strategy is a conservative approach that incrementally builds the best returning project out of all remaining available projects.

Since funding or other factors may halt ultimate completion of any implementation plan, the "maximize VHD reduction/cost" strategy provides interim systems that work – projects constructed in the early stages of the implementation plan are not dependent on the later construction of other projects to realize the full value of earlier constructed projects. Therefore, a reasonable strategy is one that provides a desirable outcome at each interim stages of implementation, since the completion of the ultimate plan as currently envisioned cannot be guaranteed, due to unforeseeable changes in funding, growth and development, construction schedules, programming priorities, and other conditions.

2 Introduction

The Greensboro Urban Area Thoroughfare Plan (GUATP) includes important conceptual roadways near Piedmont Triad International Airport (PTIA). Many of the roadways were recommended as a part of the 2004 Triad International Airport Area Transportation Study. Major roadways resulting from the study include: Airport Connector (I-73/ I-74 Connector), I-40 Connector, and the Sandy Ridge Extension. Both connectors are identified as freeways, while Sandy Ridge Extension is a major thoroughfare.

Since the release of the GUATP by the Greensboro Urban Area Metropolitan Planning Organization (GUAMPO), additional planning studies have been conducted, including the Heart of the Triad Plan and the 2035 GUAMPO Long Range Transportation Plan (LRTP). Additionally, land in and around PTIA has been identified for airport and private development. Finally, the economic landscape has greatly changed within the last year and there is a greater emphasis on cost performance of major infrastructure investment projects. As such, GUAMPO decided to revaluate the planned roadway network near PTIA to ensure that the proposed roadways are needed and cost-effective.

It should be noted that PTIA is currently conducting a study of the Airport Area including the evaluation of roadways serving the airport. However, recommendations from the PTIA study were not available before the completion of this report.

2.1 Background

The Airport Area Transportation Study was completed by NCDOT in cooperation with the Triad MPOs and Piedmont Authority for Regional Transportation (PART). The recommended roadways noted above where added to the Greensboro Urban Area Thoroughfare Plan. The study also recommended the deletion of proposed projects shown on the Greensboro Thoroughfare Plan; they included the Sandy Ridge Road Connector from Sandy Ridge Road to Pleasant Ridge Road. This project was recommended for deletion as it was determined that the connection would result in an unacceptable LOS on Pleasant Ridge Road.

The study also recommended the deletion of the Joseph M. Bryan Boulevard Extension from NC 68 to Pleasant Ridge Road. It was recommended for deletion because it was believed the cost outweighed the benefit. However, the MPO decided to retain the proposed extension of Joseph M. Bryan Boulevard to Pleasant Ridge Road.

2.2 Purpose

The purpose of the analysis is to revaluate the projects in the PTIA area, including I-73/I-74 Connector, I-40 Connector, and Sandy Ridge Road Extension. There are currently multiple combinations of twelve separate projects that could be constructed in the PTIA area. The technical evaluation of cumulative conditions in the PTIA area will support GUAMPO transportation system planning decisions and ensure that all previously identified project needs still exist and that the various proposed roadways in the area will meet these needs. Additionally, the modeling work completed for this project will be used in support of the Sandy Ridge Road Widening and Extension Feasibility Study, currently underway.

2.3 Study Area

The PTIA is located in Guilford County, close to the Forsyth County border, and is bounded by Joseph M. Bryan Boulevard to the north, W. Market Street to the south, I-73 to the east, and NC 68 to the west. PTIA is located approximately 9 miles from downtown Greensboro, 11 miles from downtown High Point, and 16 miles from downtown Winston-Salem.

The study area for this project includes portions of the Piedmont Triad Region, which encompasses the Greensboro, Winston-Salem/Forsyth, High Point, and Burlington-Graham MPOs. The Piedmont Triad Regional Travel Demand Model (PTR TDM) covers all of the MPO boundaries, though only a subarea of the total model, described as the PTIA area within this report, was utilized for detailed traffic analysis.

This study area was selected for purposes of traffic forecasting because the projects in the PTIA area have the potential to draw traffic from the local surface streets, which are often congested during the peak periods. The project study area covers a larger extent than the actual roadway improvement design limits because it is necessary to examine the regional effects of traffic diversion through the area. Figures 1 and 2 show the extents of the PTR TDM and the PTIA area (shown in black), respectively.

Figure 1. Piedmont Triad Regional Travel Demand Model Extents

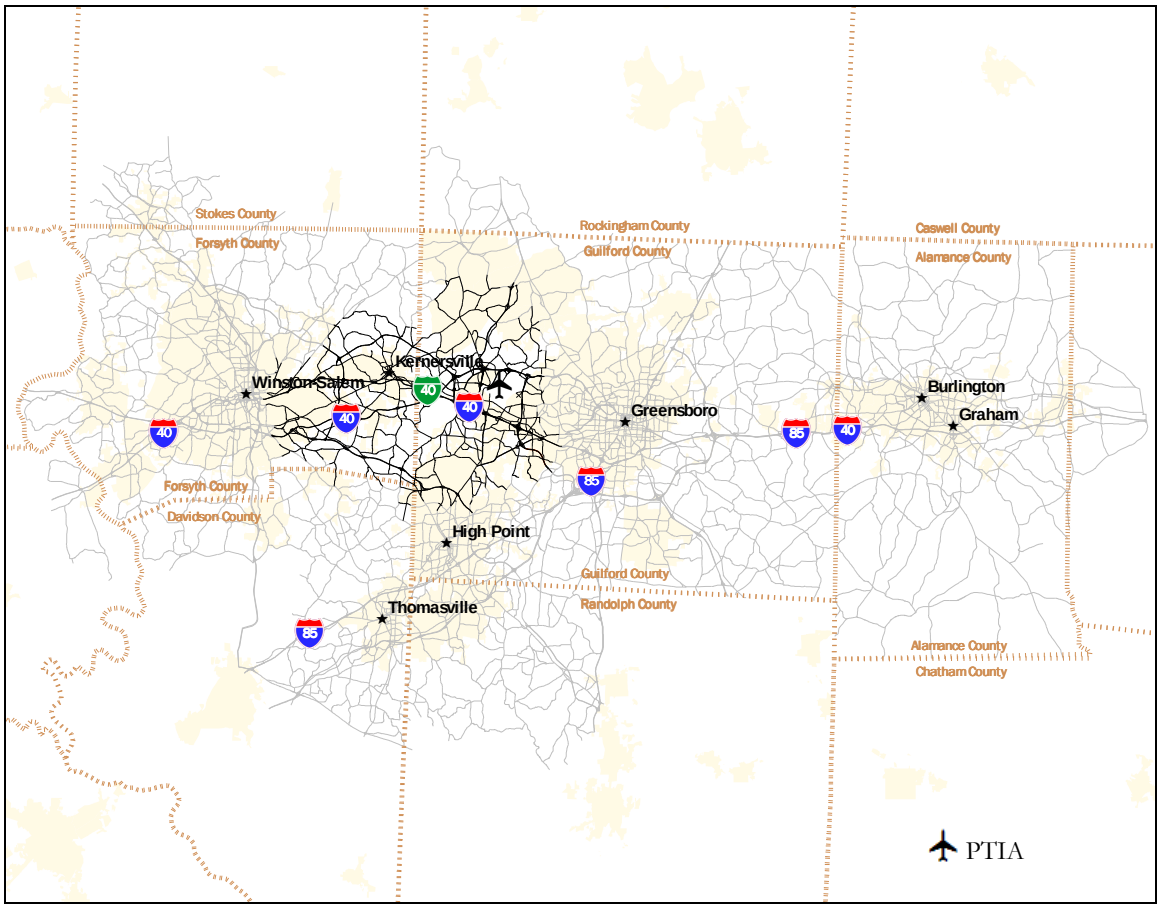
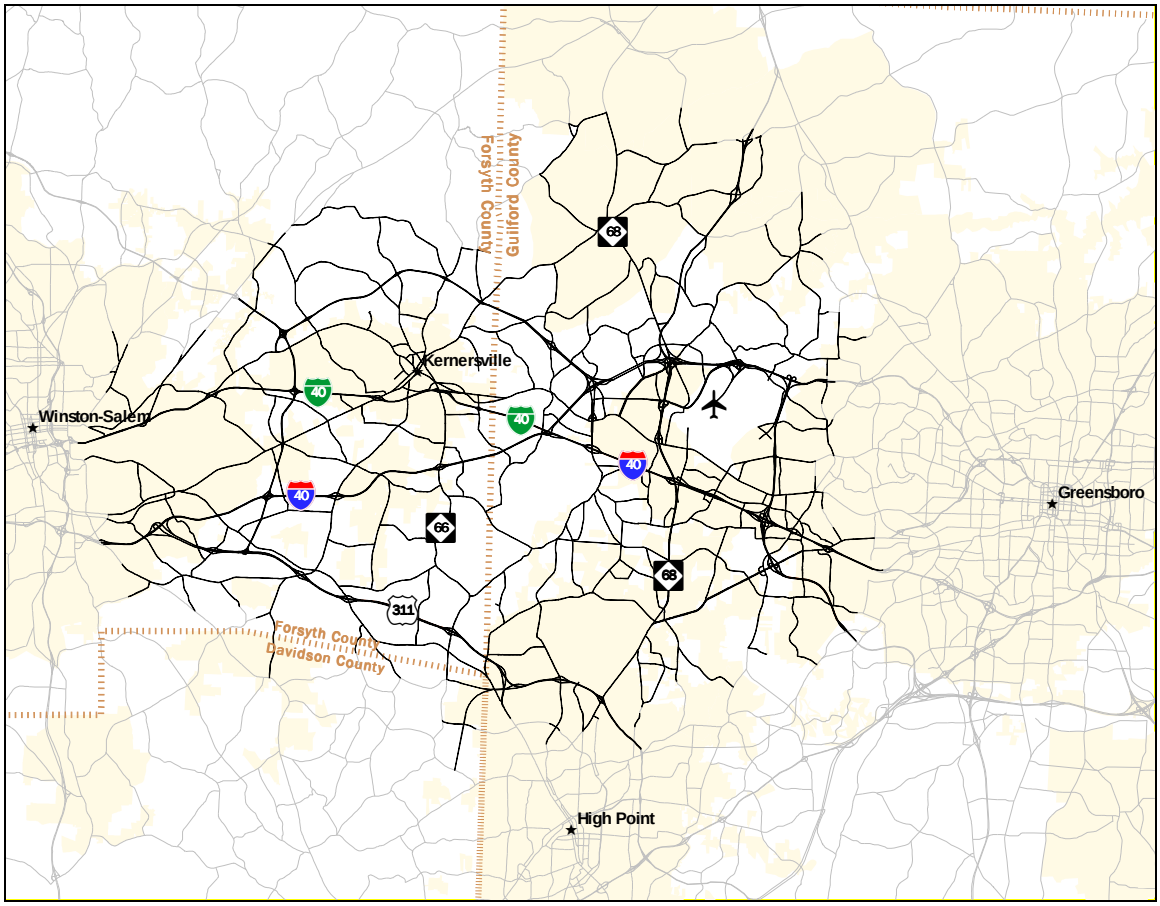


Figure 2. Piedmont Triad Airport Subarea Model Extents



2.4 Study Oversight

GUAMPO staff guided this study, though the following stakeholder group was consulted throughout the project:

- City of Greensboro Planning and Engineering
- City of High Point DOT
- City of Winston-Salem Planning and Engineering
- Town of Kernersville Public Works Department
- Piedmont Triad International Airport Authority
- Greensboro Metropolitan Planning Organization
- Winston-Salem Forsyth Metropolitan Planning Organization
- High Point Metropolitan Planning Organization
- Piedmont Authority for Regional Transportation
- North Carolina Department of Transportation

3 Projects Under Evaluation

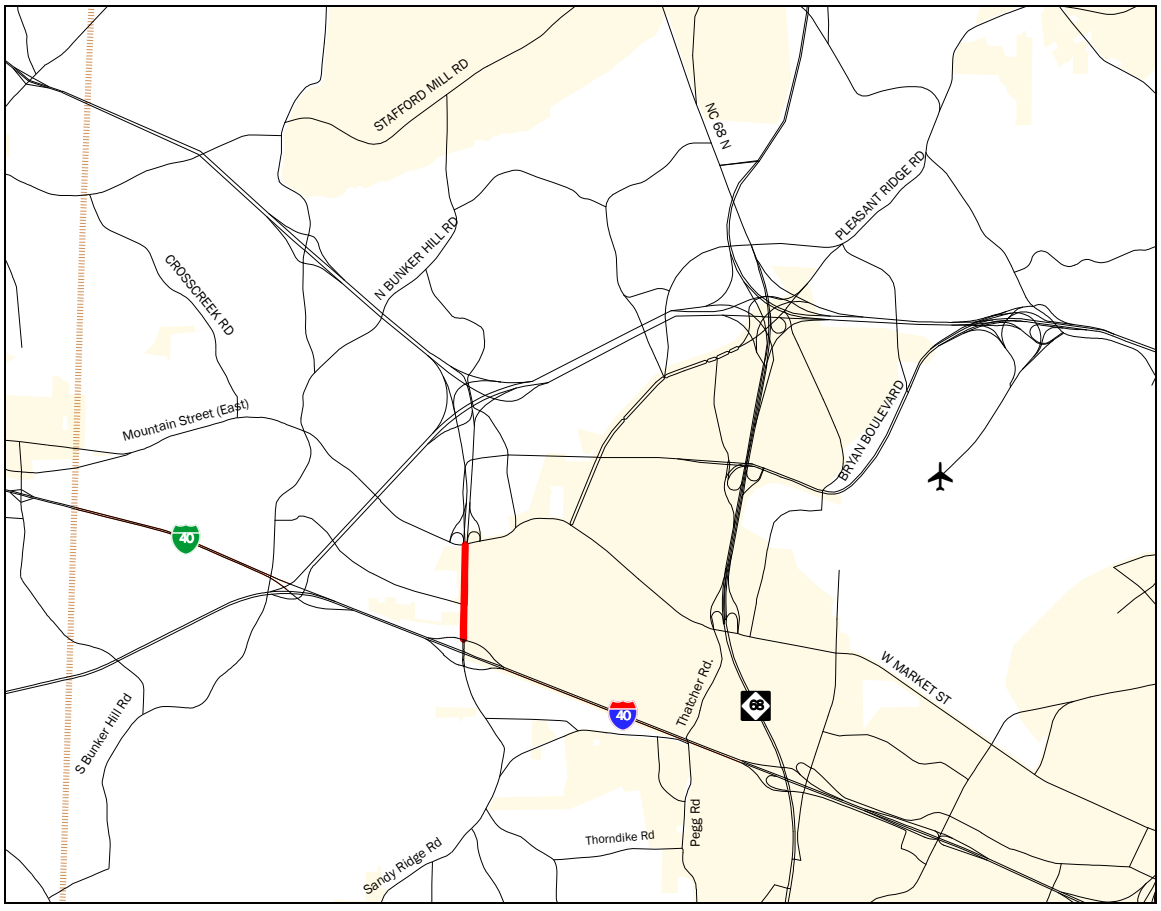
For this study, twelve projects are under consideration, some with multiple alternatives, as detailed in the following sections. Each project is designated by a letter (A-G) and a number (if there are multiple design options). Cost estimates (right of way and construction) for each project and design option are taken from the GUAMPO and WSMPO 2035 LRTPs, NCDOT feasibility studies, and NCDOT cost estimation sheets.

3.1 Sandy Ridge Road Widening

This project involves widening Sandy Ridge Road between I-40 and West Market Street. The existing Sandy Ridge Road is a collector road with one lane in each direction and no median. The proposed project widens this segment to two lanes in each direction with a median. The location of the Sandy Ridge Road widening project is shown in red on Figure 3.

- Project A1 – Existing Sandy Ridge Road – $0
- Project A2 – Widened Sandy Ridge Road – $5,554,852

Figure 3. Sandy Ridge Road Widening Project Extents

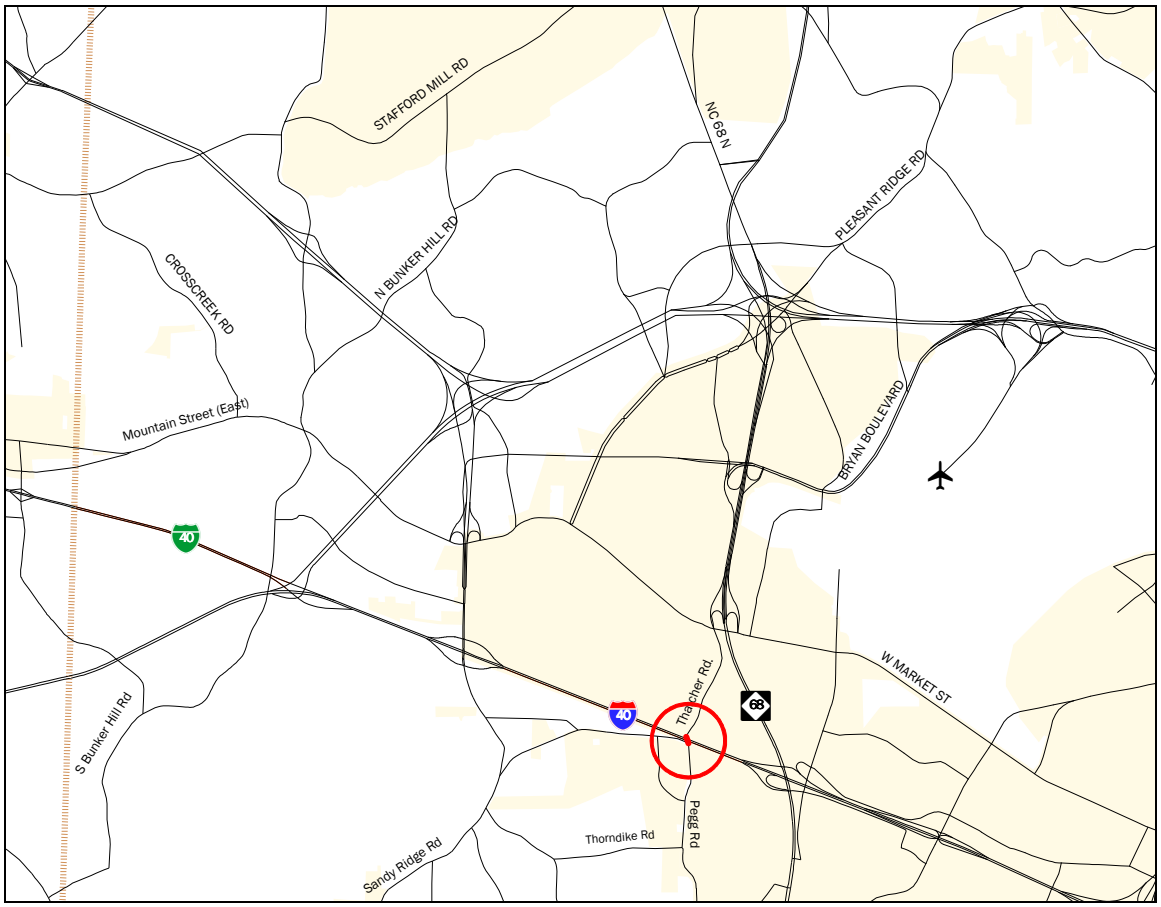


3.2 Pegg Road/Thatcher Road Connector

This project involves construction of a new facility to connect Pegg Road and Thatcher Road, which are currently separated by I-40. The proposed project adds a collector street with two lanes in each direction and a median that provides connectivity via a bridge over I-40. The location of the Pegg Road/Thatcher Road Connector project is shown in red on Figure 4.

- Project B – Pegg Road/Thatcher Road Connector – $17,855,910

Figure 4. Pegg Road/Thatcher Road Connector Project Extents

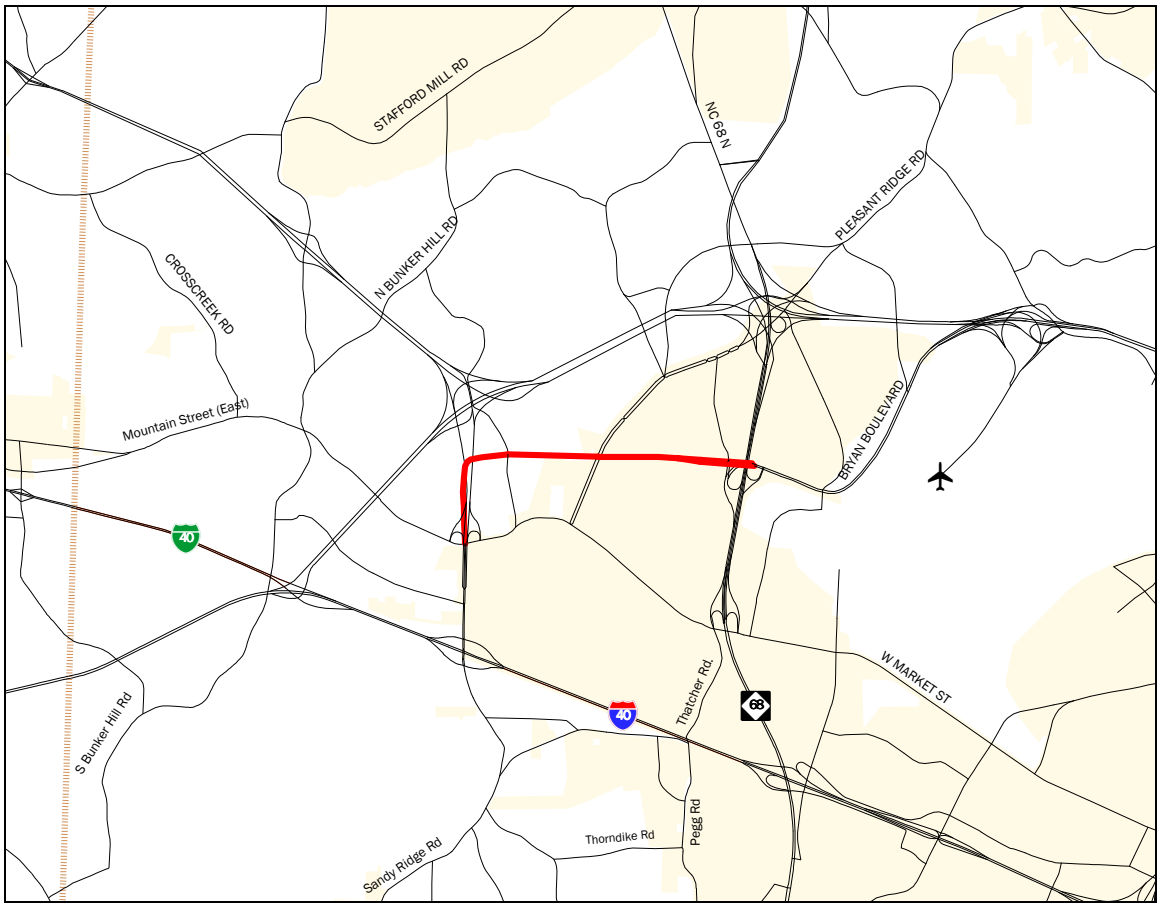


3.3 Sandy Ridge Road Extension

This project involves construction of a new facility to extend Sandy Ridge Road to either: 1) Bryan Boulevard (Eastern Extension) or 2) the proposed I-40 Connector (Northern Extension). The proposed Eastern Extension project is an arterial street with two lanes in each direction and a median that connects to Bryan Boulevard at an interchange with NC 68. The proposed Northern Extension project is a divided roadway with two lanes in each direction that connects to the proposed I-40 Connector at an interchange with the proposed I-73/I-74 and Airport Connectors. The location of the Sandy Ridge Road Extension projects are shown in red on Figures 5 (Eastern Extension) and 6 (Northern Extension).

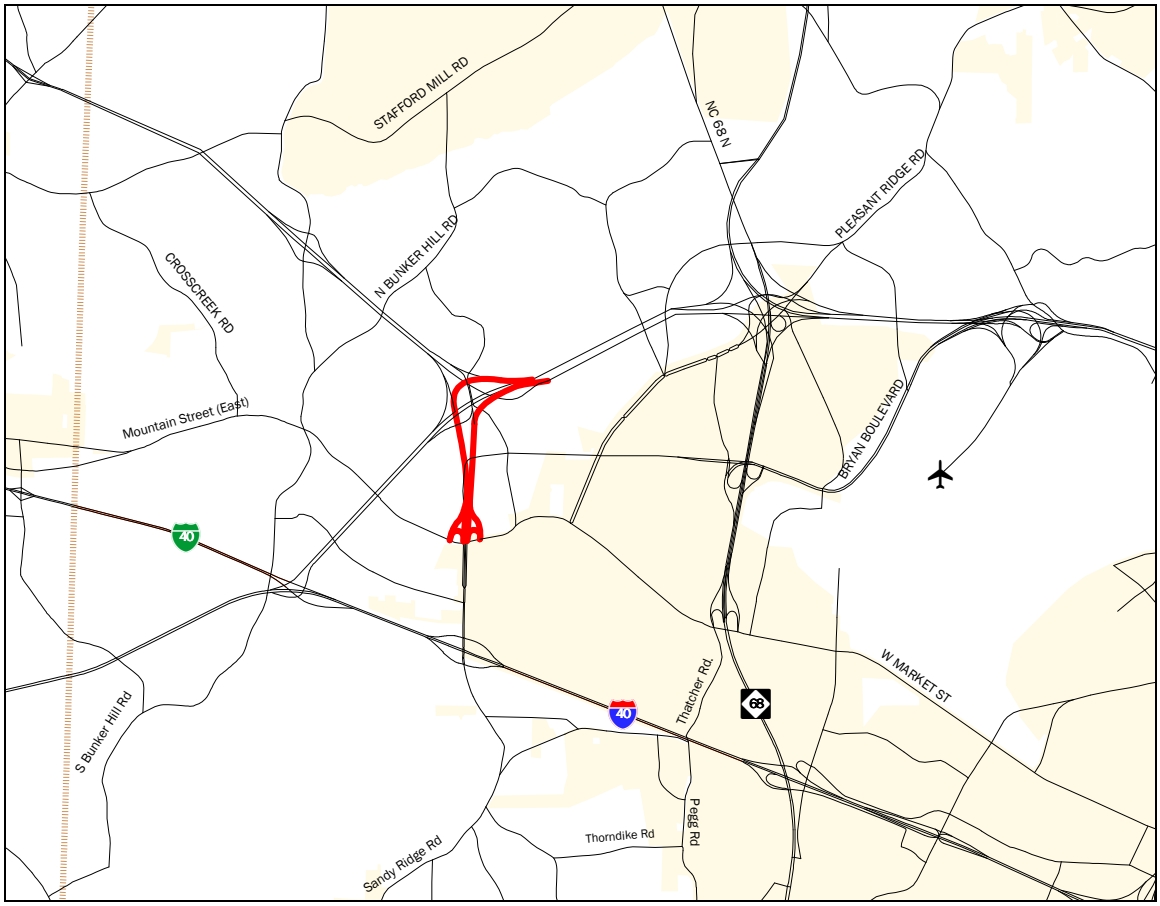
Modeling and analysis of both Sandy Ridge Road extension alternatives assumed a grade separation at West Market Street. An at-grade intersection could also be considered (either as an interim stage or as a final design), yielding substantial right-of way and construction savings.

Figure 5. Sandy Ridge Road Eastern Extension Project Extents



- Project C1 – Sandy Ridge Road Eastern Extension – $40,000,000
- Project C2 – Sandy Ridge Road Northern Extension – $22,768,800

Figure 6. Sandy Ridge Road Northern Extension Project Extents

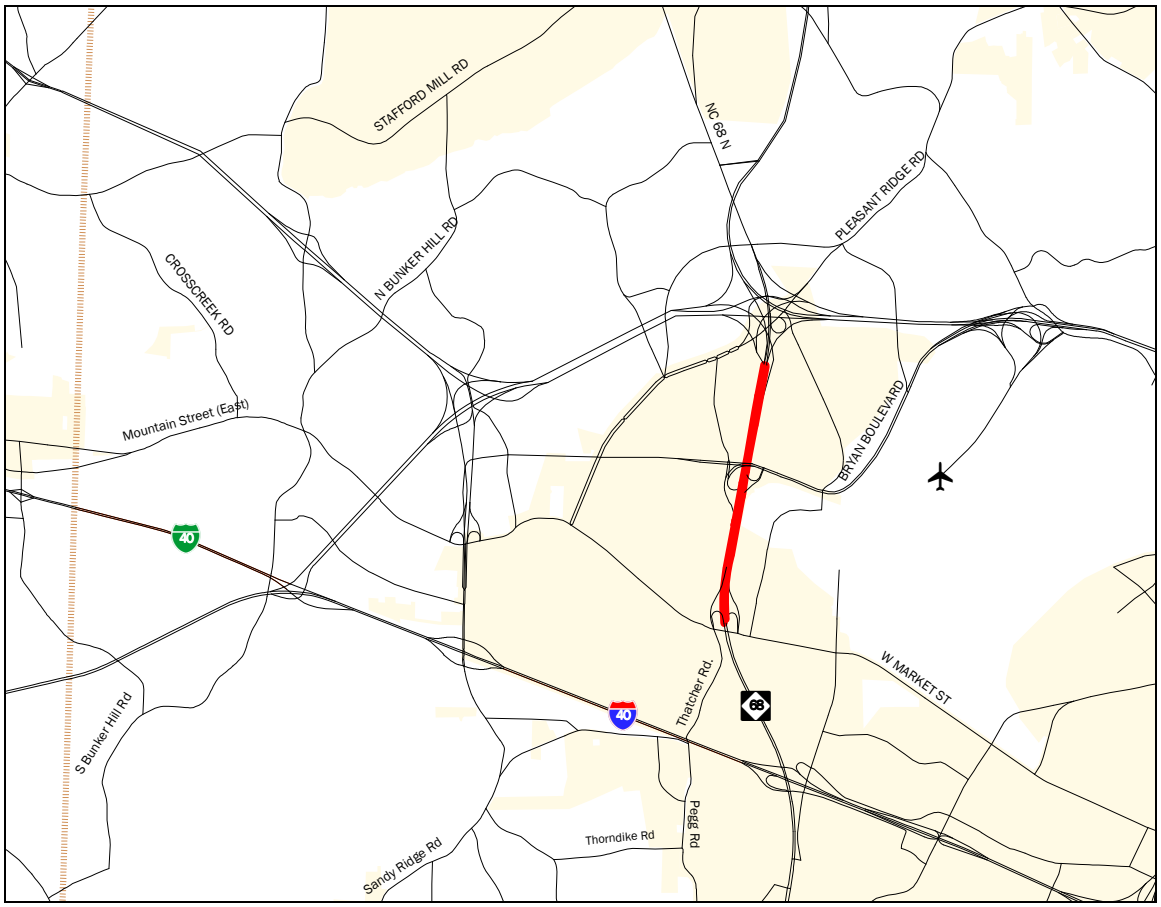


3.4 NC 68 Widening

This project involves widening a portion of NC 68 between West Market Street and Pleasant Ridge Road. The existing NC 68 is a divided highway with two lanes in each direction. The proposed project widens this section to four lanes in each direction. The location of the NC 68 widening project is shown in red on Figure 7.

- Project D1 – Existing NC 68 – $0
- Project D2 – Widened NC 68 – $58,114,585

Figure 7. NC 68 Widening Project Extents

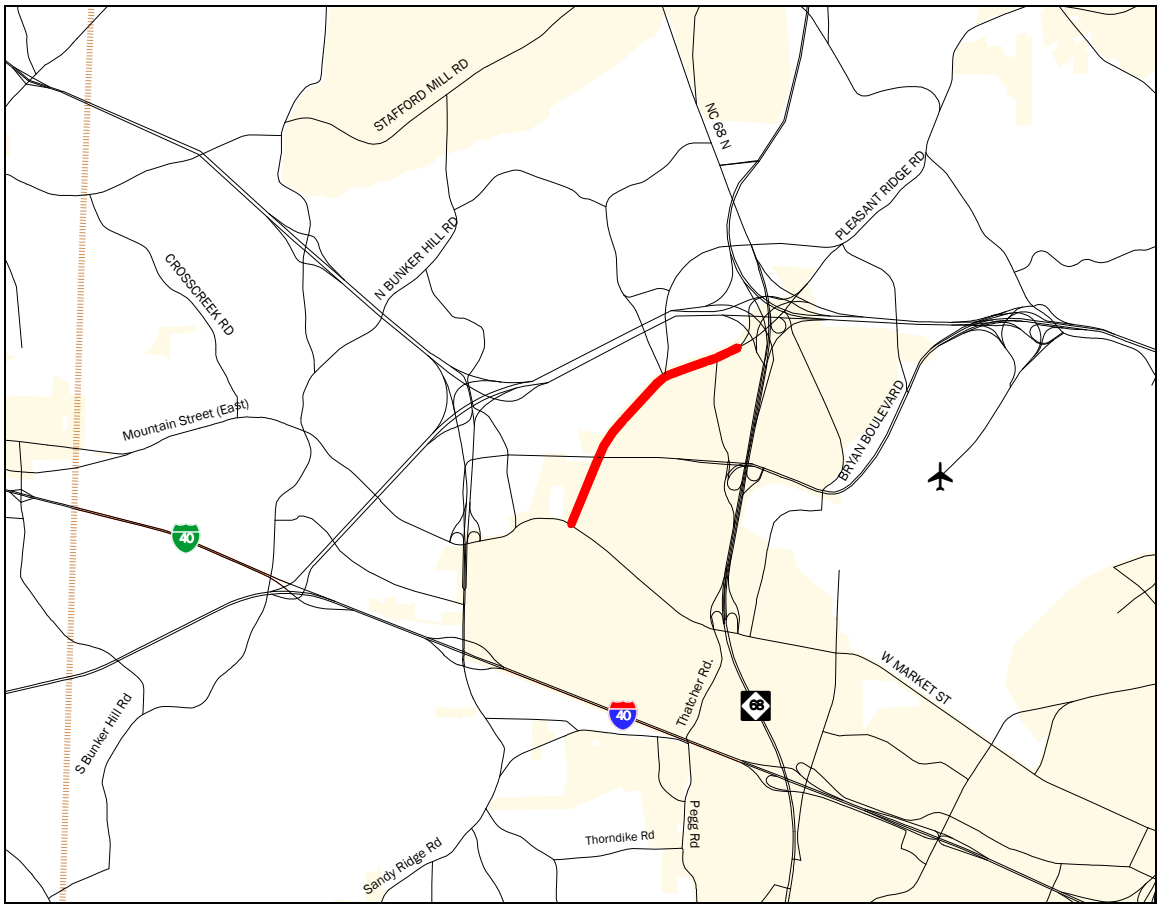


3.5 Pleasant Ridge Road Widening

This project involves widening a portion of Pleasant Ridge Road between West Market Street and Edgefield Road. The existing Pleasant Ridge Road is a rural road with one lane in each direction and no median. The proposed project widens this segment to two lanes in each direction with a median. The location of the Pleasant Ridge Road widening project is shown in red on Figure 8.

- Project E1 – Existing Pleasant Ridge Road – $0
- Project E2 – Widened Pleasant Ridge Road – $13,275,000

Figure 8. Pleasant Ridge Road Widening Project Extents

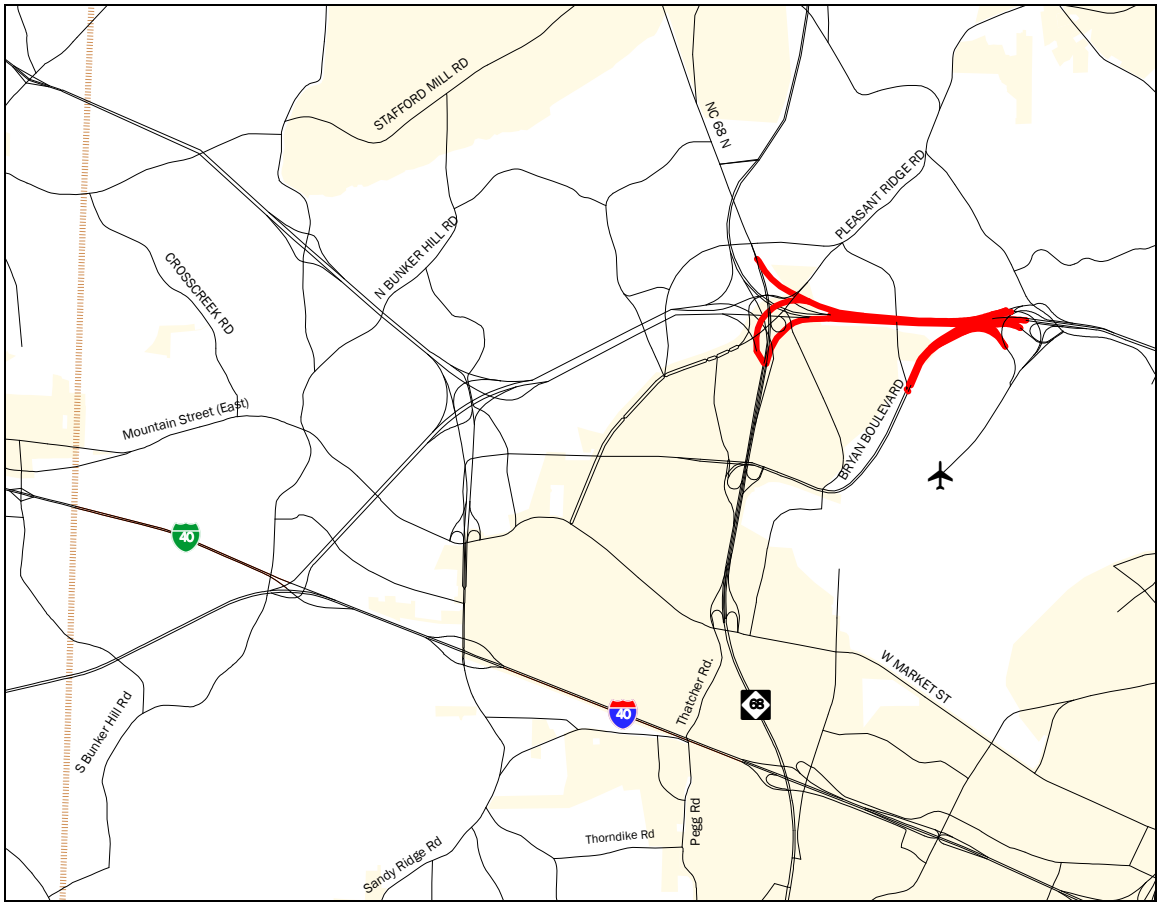


3.6 I-73 Connector

This project involves constructing a new facility between Joseph M. Bryan Boulevard and the future I-73. The proposed project is a divided freeway with two lanes in each direction. The proposed project also includes the removal of a portion of Bryan Boulevard between Caindale Drive and Old Oak Ridge Road. Additionally, the proposed project connects to the future I-73 at an interchange with NC 68 and the proposed Airport Connector. The location of the I-73 Connector project is shown in red on Figure 9.

- Project F1 – Existing Joseph M. Bryan Boulevard – $0
- Project F2 – I-73 Connector – $76,813,560

Figure 9. I-73 Connector Project Extents

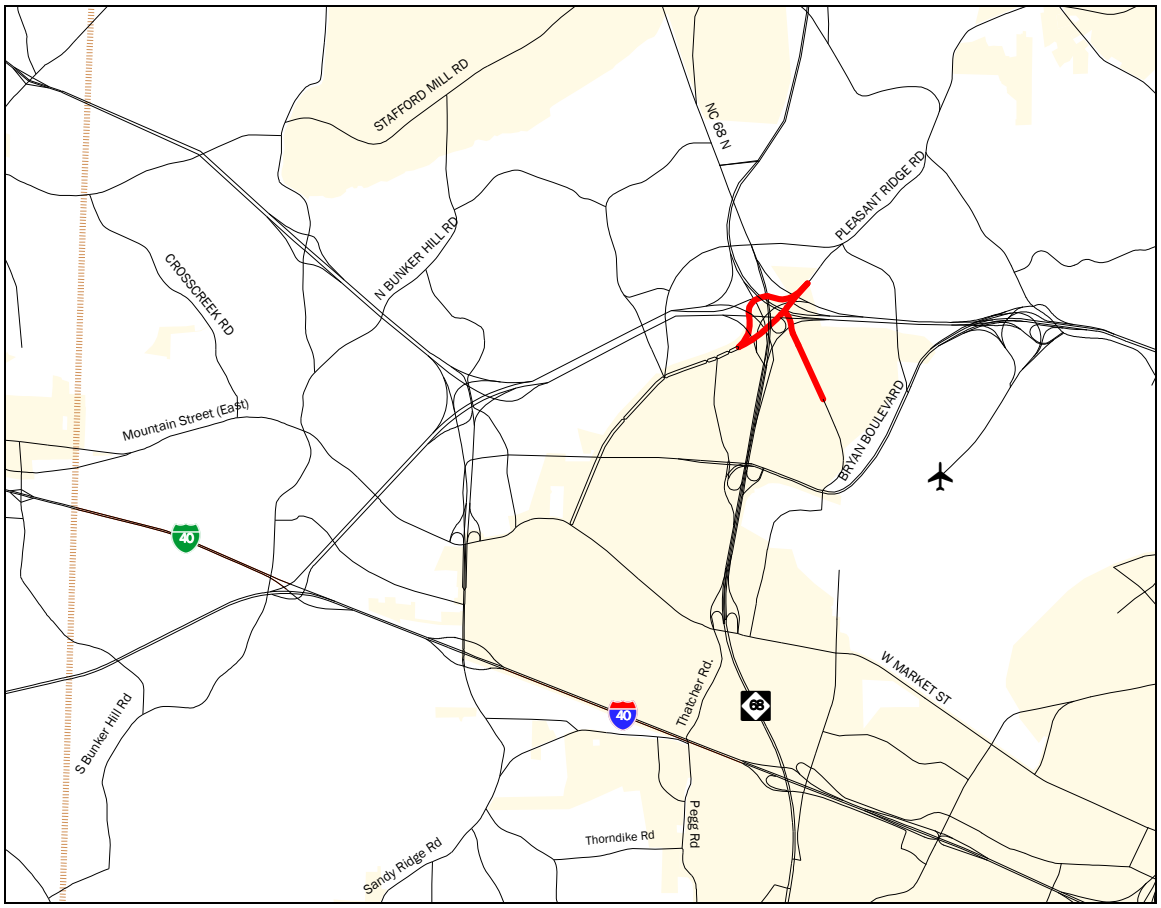


3.7 Pleasant Ridge Road Relocation

This project involves relocating a portion of Pleasant Ridge Road between Brigham Road and North Regional Road to make room for the future I-73/NC 68 interchange. The existing Pleasant Ridge Road is a rural road with one lane in each direction and no median. The proposed project widens the section to two lanes in each direction with a median located north of the current alignment. The project will have an at-grade intersection with NC 68. The location of the Pleasant Ridge Road relocation project is shown in red on Figure 10.

- Project G1 – Existing Pleasant Ridge Road – $0
- Project G2 – Relocated Pleasant Ridge Road – $14,869,268

Figure 10. Pleasant Ridge Road Relocation Project Extents



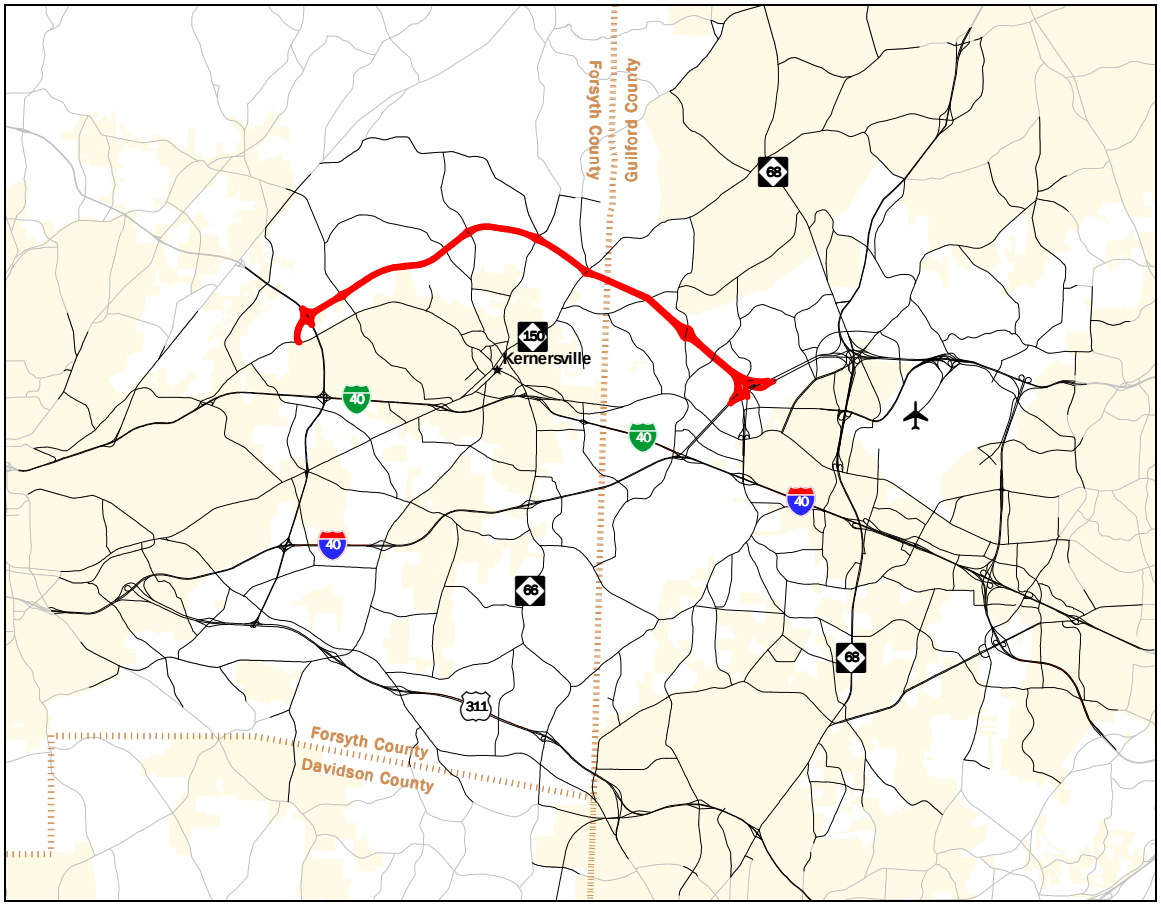
3.8 I-73/I-74 Connector

This project constructs a new facility, also known as the Kernersville Bypass, between West Mountain Street in Winston-Salem and the proposed Airport Connector. The proposed project has two options: 1) a divided freeway with two lanes in each direction or 2) an arterial street with two lanes in each direction and a median. The arterial version substitutes at-grade intersections for five of the seven interchanges in the freeway version, retaining the interchanges at the eastern and western termini.

This project connects to the proposed Airport Connector at an interchange with the proposed I-40 Connector and the Northern Sandy Ridge Road Extension. Note that the cost of this interchange is associated with the I-73/I-74 Connector project, not with the I-40 Connector, as assumed in the GUAMPO LRTP. This change was made to more accurately associate costs with the most appropriate project, given the segmentation of the Airport Connector in this analysis, and the variety of project combinations being assessed. The location of the I-73/I-74 Connector project is shown in red on Figure 11.

- Project H1 – Freeway I-73/I-74 Connector – $388,023,400
- Project H2 – Arterial I-73/I-74 Connector – $314,793,400

Figure 11. I-73/I-74 Connector Project Extents

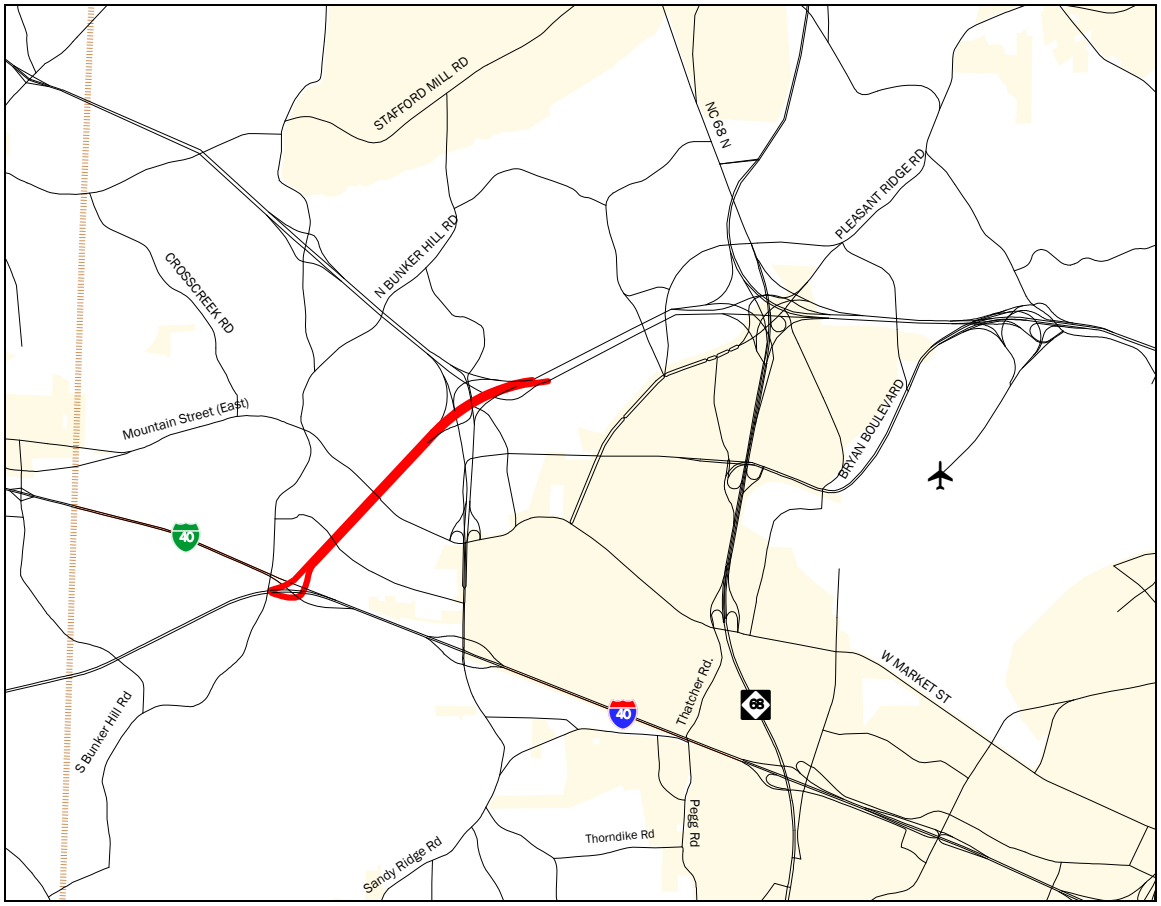


3.9 I-40 Connector

This project involves constructing a new facility between I-40 and the proposed Airport Connector. The proposed project is a divided freeway with two lanes in each direction and also includes the expansion of the I-40/Business I-40 interchange. The proposed project connects to the proposed Airport Connector at an interchange with the proposed I-73/I-74 Connector and Northern Sandy Ridge Road Extension. Note that while the GUAMPO LRTP attributes the cost of this interchange to the I-40 Connector, this analysis associates the cost of the interchange with the I-73/I-74 Connector project. Given the segmentation of the Airport Connector in this analysis, and the variety of project combinations being assessed, this change appears to more accurately associate costs with the most appropriate project. The location of the I-40 Connector project is shown in red on Figure 12.

- Project I – I-40 Connector – $46,354,000

Figure 12. I-40 Connector Project Extents

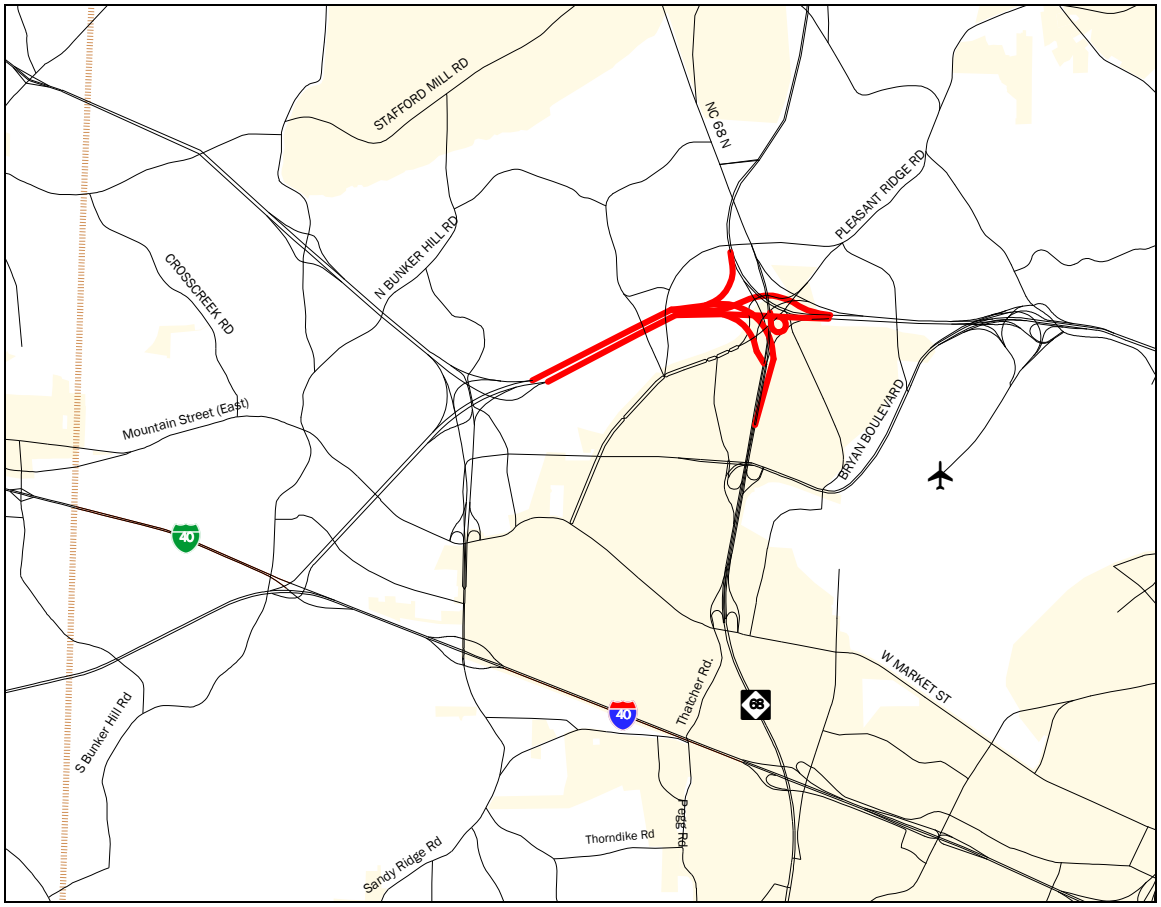


3.10 Airport Connector

This project constructs a new facility between the proposed I-73/I-74 Connector and the proposed I-73 Connector. The proposed project is a divided freeway with two lanes in each direction. This project connects to the proposed I-73/I-74 Connector at an interchange with the proposed I-40 Connector and Northern Sandy Ridge Road Extension. (As previously discussed, the cost of this interchange is associated with the I-73/I-74 Connector). Additionally, the proposed project also connects to the proposed I-73 Connector at an interchange with NC 68 and the future I-73. The location of the Airport Connector project is shown in red on Figure 13.

- Project J1 – Freeway Airport Connector – $23,125,600

Figure 13. Airport Connector Project Extents

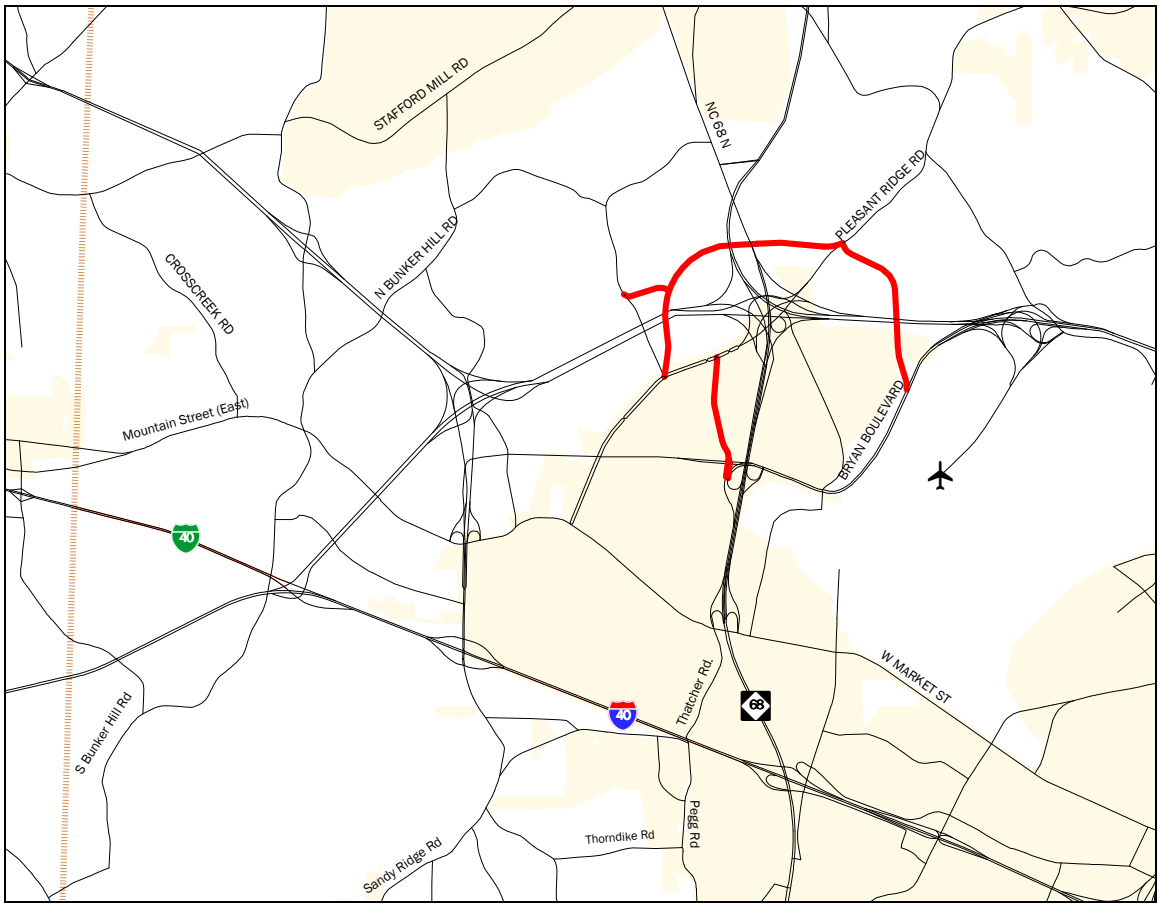


3.11 I-73 Connector Loop Roads

This project involves construction of new facilities to provide local access roads around the future I-73/proposed I-73 Connector/NC 68/proposed Airport Connector interchange. The proposed facilities are rural roads with one lane in each direction and no median. The proposed facilities will connect Joseph M. Bryan Boulevard to Pleasant Ridge Road, Pleasant Ridge Road north of the proposed I-73 Connector to Pleasant Ridge Road south of the proposed Airport Connector, and Pleasant Ridge Road south of the proposed Airport Connector to the proposed Eastern Sandy Ridge Road Extension at the Joseph M. Bryan Boulevard/NC 68 interchange. The location of the I-73 Connector Loop Roads project is shown in red on Figure 14.

- Project K – I-73 Connector Loop Roads – $37,748,635

Figure 14. I-73 Connector Loop Roads Project Extents

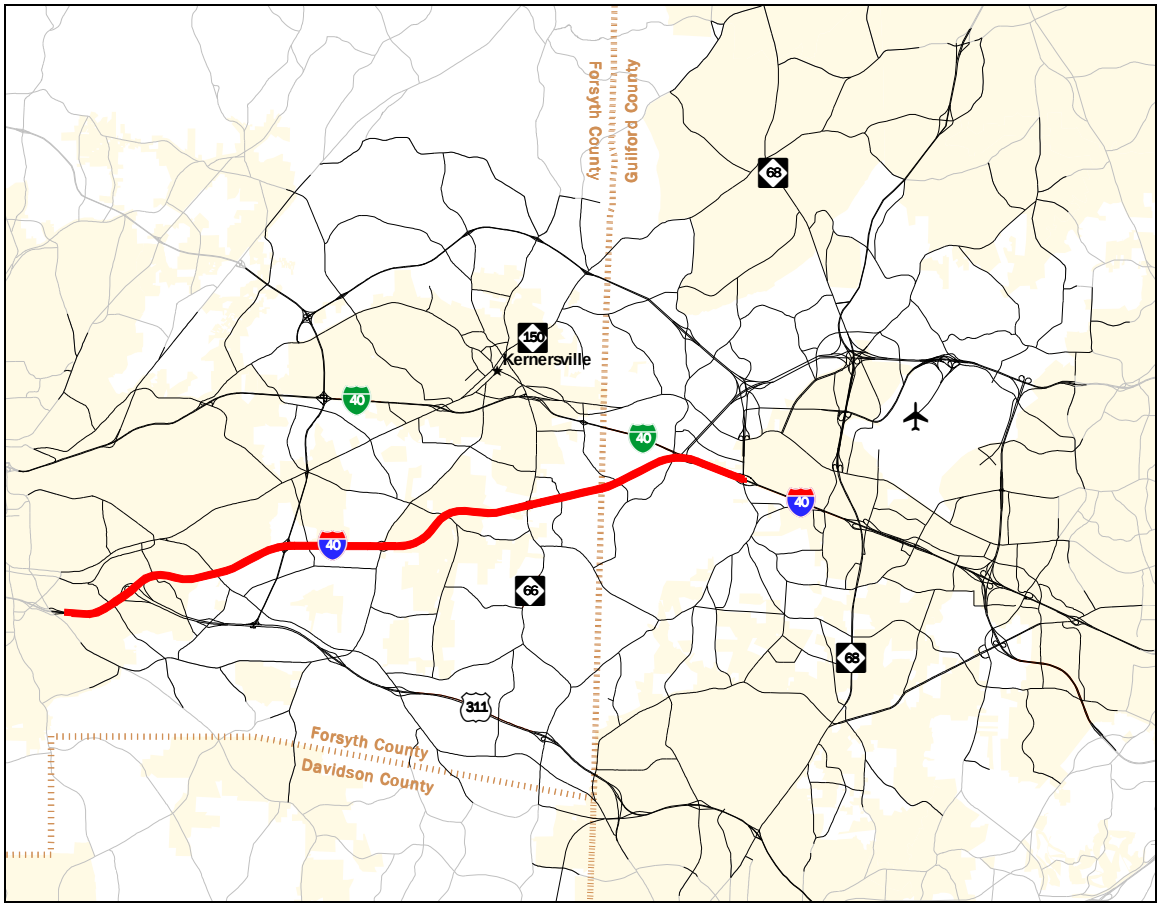


3.12 I-40 Widening

This project involves widening a portion of I-40 between NC 109 in Thomasville and NC 68 in Greensboro. Existing I-40 is a divided freeway with two lanes in each direction between NC 109 and the I-40/Business I-40 interchange and four lanes in each direction between the I-40/Business I-40 interchange and NC 68. The proposed improvements include widening to four lanes in each direction between NC 109 and the I-40/Business I-40 interchange, and widening to five lanes in each direction between the I-40/Business I-40 interchange and NC 68. The proposed project also adds loop ramps at the Old Salem Road/I-40 and Sandy Ridge Road/I-40 interchanges. The location of the I-40 widening project is shown in red on Figure 15.

- Project L1 – Existing I-40 – $0
- Project L2 – Widened I-40 – $444,100,000

Figure 15. I-40 Widening Project Extents



3.13 Evaluation Scenarios

There are 9,214 possible project scenarios, representing every possible combination of the twelve projects, ranging from solely widening Sandy Ridge Road to constructing all of the new projects listed above. The purpose of evaluating all combinations is to understand the cumulative travel benefits of individual projects, as well interactions among multiple projects. For example, both the Sandy Ridge Road widening and Extension projects may have individual benefits, but when constructed in combination, they may have even greater benefit.

4 Travel Demand Model Review

A critical component of the traffic analysis for this project is the preparation of year 2035 subarea traffic forecasts for project scenario testing. Because results from this study will be used for the Sandy Ridge Feasibility Study, it is important that the subarea traffic forecasting approach be consistent with adopted regional data and procedures. This chapter documents the approach for developing year 2035 subarea traffic forecasts using the TransCAD software package.

4.1 Use of the Piedmont Triad Regional Travel Demand Model

A key input into the process is the 2002 approved version of the Piedmont Triad Regional Travel Demand Model. This model utilizes the TransCAD software platform along with recent land use and road network information to forecast the regional demand to 2035. The base year model is calibrated for 2002 conditions and the forecast year model represents 2035 conditions. The model was developed for the entire Piedmont Triad Regional area and includes detailed zone and network systems within Forsyth, Guilford, and Alamance Counties. The model also includes portions of Davidson and Randolph Counties.

4.2 Land Use Assumptions

One of the primary inputs for the PRT TDM is land use data, which is used to estimate trip generation information. Land use information is summarized within traffic analysis zones (TAZs), which represent geographical boundaries that contain many individual parcels. The PRT TDM employs eight land use data categories for each TAZ:

- Households
- School Students
- Highway Retail Employees
- Industrial Employees
- Retail Employees
- Service Employees
- Office Employees
- School Employees

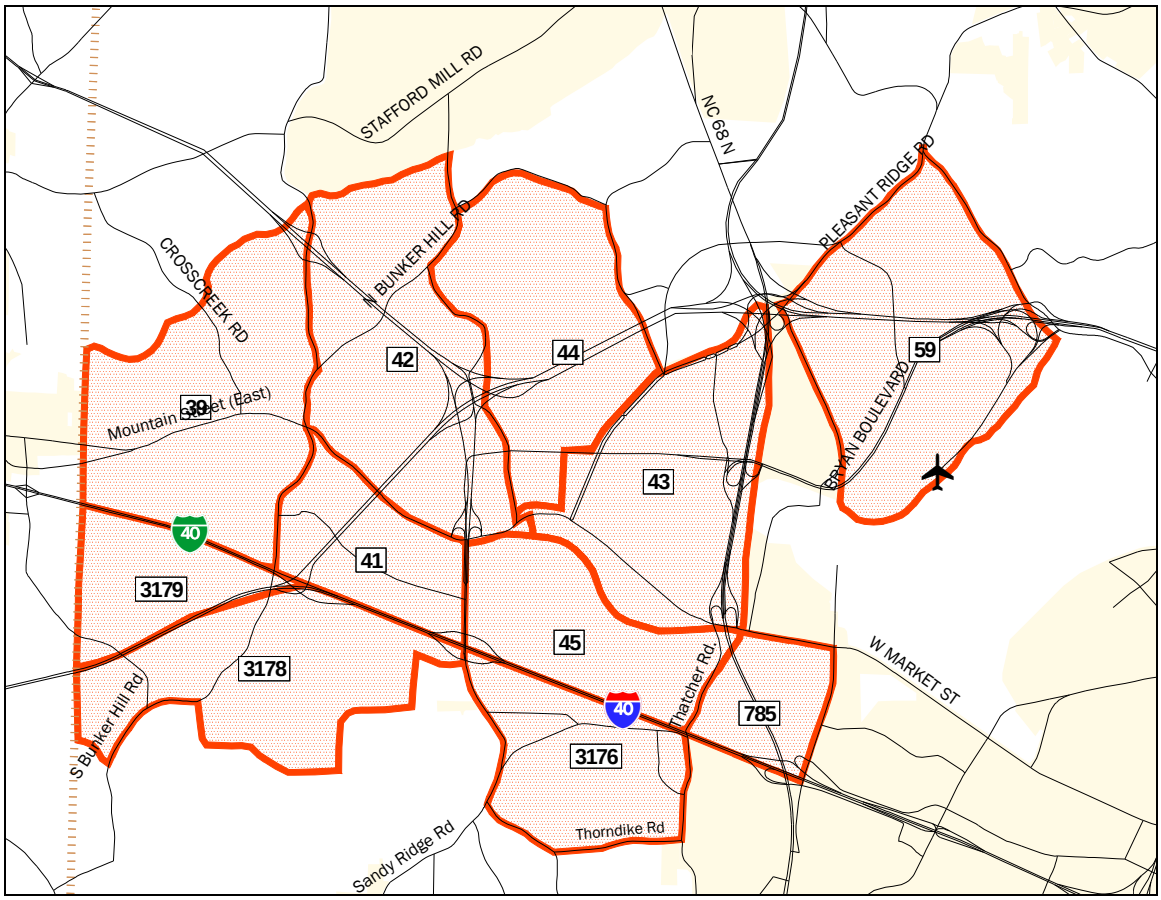
For the purposes of this study, the land use data contained in the approved 2009 and 2035 Existing + Committed (E+C) scenarios was used. However, the land use forecast within the PTIA area was thoroughly reviewed by GUAMPO staff and adjusted to account for recent development proposals that could significantly affect the future transportation network planning in the area.

GUAMPO staff recommended changes within the PTIA area, which were included in the land use assumptions for the 2035 model runs, as shown in Table 2 and Figure 16:

Table 2. 2035 Land Use Changes

TAZ	HH	HWY RET	IND	RETAIL	SERVICE	OFFICE	SCHOOL
Existing 2035 Data							
39	0	0	438	21	61	57	0
41	92	412	0	260	391	0	0
42	467	9	509	147	561	0	107
43	0	0	3,329	430	1,318	0	0
44	407	26	432	225	232	84	0
45	0	141	2,714	3,046	1,096	1,298	0
59	0	39	2,887	1,064	3,256	1,662	0
785	0	0	2,124	1,667	3,024	433	0
3176	0	0	634	2,749	1,386	463	0
3178	0	193	7	514	1,181	50	0
3179	0	0	0	0	0	0	0
Land Use Changes							
39	0	0	+380	+18	+53	+49	0
41	+500	+2,294	0	+1,448	+2,178	0	0
42	-300	+17	+966	+279	+1,065	0	+203
43	0	0	-1,134	-146	-449	0	0
44	-200	+66	+1,094	+570	+587	+213	0
45	0	-60	-1,146	-1,287	-463	-548	0
59	0	-9	-648	-239	-731	-373	0
785	0	0	-1,245	-977	-1,772	-254	0
3176	0	0	-12	-53	-26	-9	0
3178	0	-10	0	-26	-61	-3	0
3179	0	0	+100	+64	+30	+6	0
Airport Area Study 2035 Data							
39	0	0	818	39	114	106	0
41	592	2,706	0	1,708	2,569	0	0
42	167	26	1,475	426	1,626	0	310
43	0	0	2,195	284	869	0	0
44	207	92	1,526	795	819	297	0
45	0	81	1,568	1,759	633	750	0
59	0	30	2,239	825	2,525	1,289	0
785	0	0	879	690	1,252	179	0
3176	0	0	622	2,696	1,360	454	0
3178	0	183	7	488	1,120	47	0
3179	0	0	100	64	30	6	0

Figure 16. 2035 Land Use Changes TAZ Map



4.3 Roadway Network Assumptions

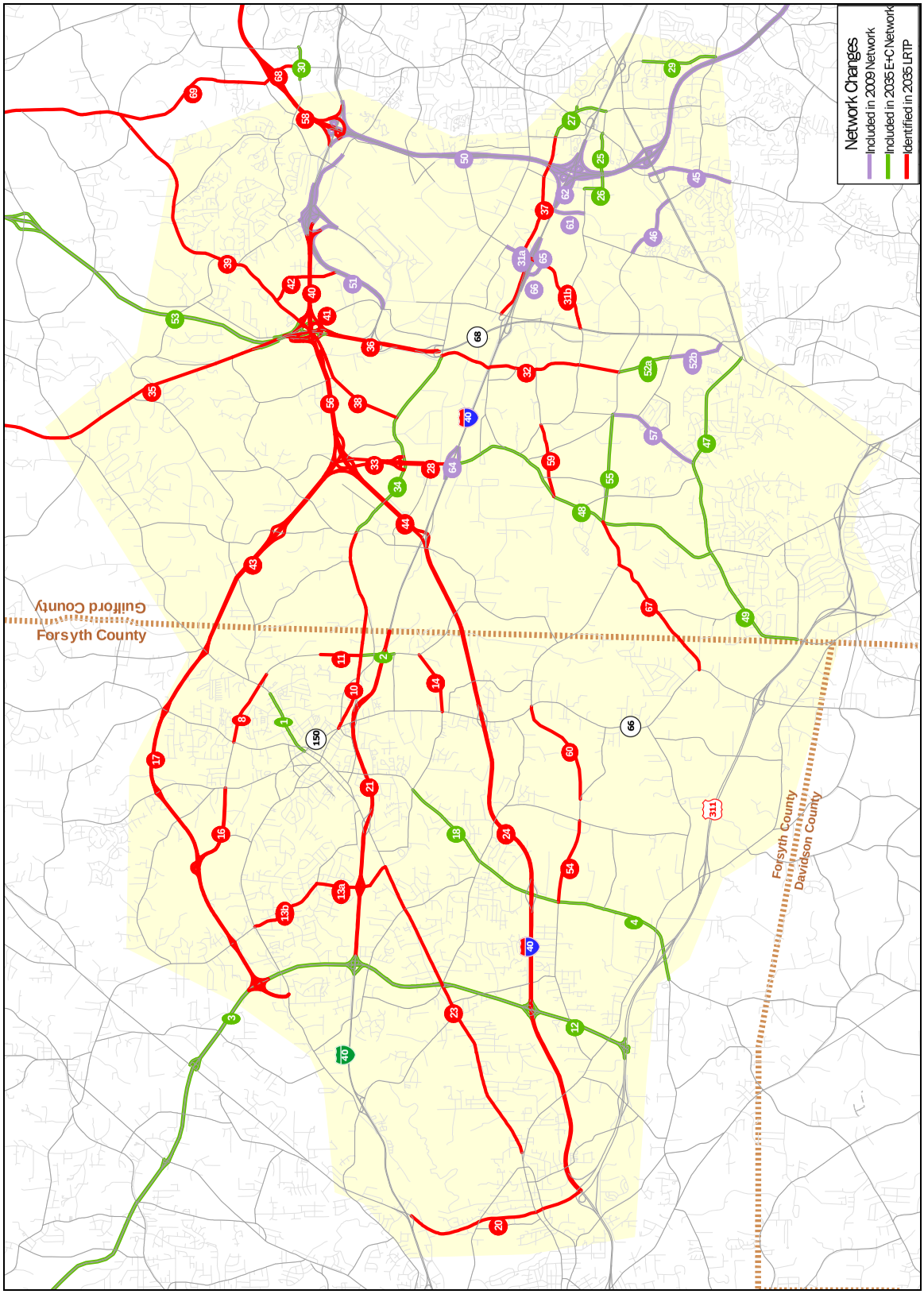
The roadway network for the 2009 and 2035 E+C conditions is based on the 2008 approved model roadway centerline file. The model roadway networks include all state routes, arterials, collectors, and important local roads within the study area. The roadway network database includes street name, distance, and generalized functional class. In addition to these attributes, speed, capacity, number of lanes, median presence, and signals per mile were coded. The roadway attributes are used by the travel demand model to estimate the vehicular capacity for each roadway segment.

The 2009 model roadway network represents existing conditions and includes only roadways operational in 2009. The 2035 E+C model roadway network includes both existing roadways and roadway projects with funding commitments that are anticipated to be operational by 2035. There are a number of proposed roadway improvements in the PTIA area that are accommodated in the forecasting process based on input from the Steering Committee. The Piedmont Triad Regional Travel Demand Model was inspected and modified to ensure that the 2035 roadway network included the improvements listed in Table 3 and shown on Figure 17. Projects identified in the area 2035 LRTPs are also listed in the table and figure, which include the twelve projects under evaluation in the PTIA area.

Table 3. Network Changes Description

ID	Project Name	Project Limits	Existing	Proposed
		Included in 2009 Network		
31a	Gallimore Dairy Road	International Drive to Albert Pick Rd	2 lane	4 lane divided
45	Guilford College Road (SR 1546)	High Point Rd (SR 4121) to south of Wendover Ave (SR 1541)	2 lane	4 - 5 lane
46	Piedmont Parkway Extension	Tarrant Road to W. Wendover Avenue		4 lane divided
50	I-840	Bryan Boulevard to I-85		6 lane freeway
51	Bryan Boulevard Extension / Relocation	Old Oak Ridge Road to Regional Road		4 lane freeway
52b	Penny Road	NC 68 to Willard Dairy Road		4 lane divided
57	Barrow Road	Clinard Farms Road to Skeet Club Road		4 lane divided
61	Boulder Road	Chimney Rock Road to Burnt Poplar Rd		2 lane undivided
62	Chimney Rock Road	Hornaday Road Extension to Burnt Poplar Rd	2 lane	remove road
64	Sandy Ridge Road Ramps to I-40	I-40 at Sandy Ridge Road	ramps	standard diamond
65	Gallimore Dairy Road Ramps to I-40	I-40 at Gallimore Dairy Road		diamond and butterfly ramps
66	Albert Pick Road	Albert Pick Road to Gallimore Dairy Road (relocation)	2 lane	2 lane undivided
		Included in 2035 E+C Network		
1	North Main Street (NC 150)	NC66 to Clay Flynt Road		3 lane
2	SR 2601 (Macy Grove Road)	New Location and Convert Grade Separation at I-40 Business to an Interchange.		Build Interchange ; 4 lane divided
3	74)	(Reidsville Road)		New 4 - 6 lane freeway
4	Union Cross Road (SR 2643)	I-40 to High Point Road	2 lane	3 lane and 4 lane divided
12	74)	(Reidsville Road) to US 52)		New 4-6 lane divided
18	Union Cross Road (SR 2643)	Widening from Wallburg Road (SR 2691) to Whicker Road (SR 2640)	2-3 lane	4 lane divided
25	Hornaday Road Extension	Hornaday Road to Chimney Rock Road		3 lane
26	Hornaday Road Bridge	Grade Separation over Greensboro Urban Loop		3 lane
27	Bridford Parkway Extension	Hornaday Road to Burnt Poplar Road		4 lane divided
29	Stanley Road	Koger Boulevard to Hilltop Road	2 lane	5 lane
30	Horsepen Creek Rd / Fleming Rd Connector	Isaacson Boulevard to Inman Road		4 lane divided
34	West Market Street	Bunker Hill Road to NC 68	2 lane	4 lane divided
47	Skeet Club Road	NC 68 to Johnson Street	2 lane	4 - 5 lane
48	Johnson Street/Sandy Ridge Road	Skeet Club Road to I-40	2 lane	4 lane divided
49	Skeet Club Road	Johnson Street to US 311	2 lane	4 - 5 lane
52a	Penny Road	Willard Dairy Road to Clinard Farms Road		4 lane divided
53	NC 68 / US 220 Connector	NC 68 to US 220		4 lane freeway
55	Piedmont Parkway Extension	Johnson Street to Barrow Road		4 lane divided
		Identified in 2035 LRTP		
8	N. Main St./Piney Grove Rd. Connector	North Main Street (NC 150) to Piney Grove Road (SR 1969)		New 4 lane divided
10	1008	NC 66 to SR 2001 (Winthrop Street) in Guilford County. Widen to Multi-Lanes.	2 lane	5 lane
11	Macey Grove Road Extension (North)	SR 1005 (East Mountain Street) to NC 150 (North Main Street).		New 4 lane divided
13a	Business I-40 (US 421) Interchange at Big Mill Farm Road	Hopkins Road to S. Main Street		New Interchange 4 lane divided
13b	Business I-40 (US 421) Interchange at Big Mill Farm Road	Hopkins Road to NC 66		4 lane divided
14	Macey Grove Road Extension (South)	NC 66 to Industrial Park Drive		New 4 lane divided
16	Linville Springs Road (SR 2030) Extension	Piney Grove Road (SR 1969) to I-73/74 Connector (Regional Aiport Connector)		New 4 lane divided
17	I-73 - I-74 Connector	Northern Beltway/West Mountain Street to Guilford County		New 4 lane freeway
20	US 311 Connector	I-40 to Business I-40		New 4 lane divided
21	Business I-40 (US 421)	Northern Beltway to Guilford County	4 lane freeway	6 lane freeway
23	Kernersville Road (SR 4315)	High Point Road (SR 1003) to Whicker Road	2 lane	3 lane
24	I-40	US 311 to Business 40 Split	4 lane freeway	6 lane freeway
28	Sandy Ridge Road	I-40 to West Market Street	2 lane	4 lane divided
31b	Gallimore Dairy Road	NC 68 to Albert Pick Rd	2 lane	4 lane divided
32	Pegg / Thatcher Connector	W Market Street to Clinard Farms Rd		4 lane divided
33	Sandy Ridge Road Extension	West Market Street to I-40 / NC 68 / I-73 Connector		4 lane divided
35	NC 68	Peeples Road to Rockingham County	2 lane	4 lane divided
36	NC 68	Market Street to Pleasant Ridge Road	4 lane	6 lane divided
37	Burnt Poplar Road	Swing Road to Regional Road	2 lane	3 lane
38	Pleasant Ridge Road	West Market Street to City Limits	2 lane	4 lane divided
39	Pleasant Ridge Road	City Limits to Old Oak Ridge Rd	2 lane	4 lane divided
40	I-73 Connector	NC 68 to Bryan Boulevard		4 lane freeway
41	Pleasant Ridge Road Relocation at I-73 Connector	Montmartre Road to Cude Road		3 lane
42	Bryan Boulevard Loop at I-73 Connector	Montmartre Road to Pleasant Ridge Road		4 lane divided
43	I-73 - I-74 Connector	Forsyth County to NC 68		4 lane divided
44	I-40 Connector	I-40 to I-73 / I-74 Connector		4-6 lane freeway
54	Glenn High Road Extension	Union Cross Road to Teague Lane		4 lane divided
56	Airport Connector	I-73 - I-74 Connector to NC 68		4 lane freeway
58	I-840	Bryan Boulevard to US 220 / US 29		6 lane freeway
59	Thorndike Road	Gallimore Dairy Road to Sandy Ridge Road		2 lane undivided
60	Bunker Hill Sandy Ridge Road	NC 66 to Teague Lane		4 lane divided
67	Winston-Salem North/South Connector	NC 66 to Johnson Street on Squire Davis Road / Sandy Ridge Road	2 lane	4 lane undivided
68	Flemington-Lewiston Connector	Fleming Road to Lewiston Road Connection		4 lane divided
69	Lewiston Road / Pleasant Ridge Road	Urban Loop to NC 150 Relocation	2 lane	4 lane divided

Figure 17. Network Changes Map



4.4 Performance Testing

Model validation is the term used to describe how closely the model's output matches existing travel data in the base year. The 2008 approved model met NCDOT travel demand model validation guidelines, and base year performance was deemed acceptable. However, the NCDOT validation guidelines measure only the model's ability to replicate a static set of conditions (traffic counts). While this provides useful information, its value is limited because the purpose of this study is to forecast how changes in the roadway network would change traffic conditions.

A more valid test of a model's accuracy would focus on the model's ability to predict realistic differences in outputs as inputs are changed; in other words, dynamic validation rather than static validation. In order to review the model's dynamic validation within the PTIA area, the following two tests were performed.

The first test was to see how the model responds to the removal of a link in the road network. For this test, a critical north-south connection was removed, NC 68 between the I-40 on- and off-ramps. Table 4 summarizes the results of this test. The majority of traffic is rerouted to the four parallel connections. As would be expected, there is a small drop in total traffic, since increased congestion and less direct access across I-40 shifts some of the trips to other crossing points along I-40 outside of the testing area.

Table 4. Removal of a Link in the Network

I-40 Overcrossing	With NC 68	Without NC 68	Ratio
Sandy Ridge Road	15,187	20,189	1.33
NC 68 NB	14,565	0	n/a
NC 68 SB	16,497	0	n/a
Gallimore Dairy Road	11,065	22,277	2.01
South Regional Road	7,851	8,808	1.12
Chimney Rock Road	12,890	13,730	1.07
Total	**78,055**	**65,004**	**0.83**

The second test assessed the model response to adding a link to the road network. For this test, the proposed Pegg Road/Thatcher Road extension under I-40 was added. Table 5 summarizes the results of this test. Again, as would be expected, traffic decreases on the five parallel roadways and is rerouted to take advantage of the new capacity on Thatcher Road. In addition, there is a small increase in the total amount of traffic, due to the induced demand of additional roadway facilities.

Table 5. Addition of a Link to the Network

I-40 Overcrossing	Without Thatcher Road Connection	With Thatcher Road Connection	Ratio
Sandy Ridge Road	15,187	12,377	0.81
Thatcher Road	0	6,812	n/a
NC 68 NB	14,565	14,296	0.98
NC 68 SB	16,497	14,890	0.90
Gallimore Dairy Road	11,065	10,195	0.92
South Regional Road	7,851	7,235	0.92
Chimney Rock Road	12,890	12,806	0.99
Total	**78,055**	**78,611**	**1.01**

The results of the dynamic validation tests confirm that the model produces reasonable results for the model application this study requires.

5 Travel Demand Model Forecasting Methodology

This chapter describes the methodology used to develop traffic forecasts for the various projects in the PTIA area. Each step is described in more detail below.

5.1 2035 E+C Model Base Run

A full execution of the Piedmont Triad Regional Travel Demand Model requires approximately twelve hours to complete, while the traffic assignment portion alone requires approximately two hours. Given the number of scenarios that are under evaluation, it would take approximately twelve years to fully execute the model for each scenario. For these reasons, the use of a subarea model representing a smaller geographic portion of the Piedmont Triad Regional Travel Demand Model was selected for this study.

In support of this approach, the 2035 E+C Piedmont Triad Regional Travel Demand Model was run with the land use and roadway network changes described in the previous chapter to develop the baseline origin-destination information for the subarea model. The PM peak hour subarea origin-destination trip tables from the 2035 E+C Piedmont Triad Regional Travel Demand Model were extracted for use in the subarea model.

5.2 Subarea Model Development

To decrease the time required to perform individual scenario runs, the full Piedmont Triad Regional Travel Demand Model was used for the trip generation, trip distribution, and mode choice steps, while the subarea model was used for traffic assignment steps within the project study area. Additionally, the traffic assignment step within the subarea was further streamlined by collapsing the number of vehicle classification bins from 14 (single occupant vehicle, single occupant vehicle toll, high-occupancy vehicle 2, high-occupancy vehicle 2 toll…) to two (personal vehicle and commercial/heavy vehicles). The resulting subarea model required approximately 30 seconds to complete the traffic assignment step within the study area.

5.3 Subarea Model Scenario Runs

A subarea model batch routine was created to execute the traffic assignment step for all of the project scenarios. This took approximately 77 hours to complete using the origin-destination information from the full 2035 E+C Piedmont Triad Regional Travel Demand Model. Twenty-five sets of the resulting traffic forecasts data were reviewed in detail to ensure that the project scenarios were correctly coded and that the resulting traffic forecasts were reasonable.

6 Subarea Model Results

6.1 Traffic Statistics

The travel demand forecasting for this project was accomplished using a combination of the most recent Piedmont Triad Regional Travel Demand Model (with land use and roadway network modifications as previously described) and a subarea travel demand model representing a portion of the model within the PTIA area.

It is important to recognize that regional models such as the Piedmont Triad Regional Travel Demand Model typically represent only major components of the roadway network and are calibrated/validated to the level of screenlines and major corridor volumes. These models are best-suited to forecast regional-level traffic patterns, and usually lack sufficient detail to provide reasonable forecasts at the intersection turning movement level.

As a result, specific traffic volumes were not used as performance measures; rather the following aggregate statistics were calculated over the entire subarea for each scenario:

- Vehicle miles traveled (VMT)
- Vehicle hours traveled (VHT)
- Vehicle hours of delay (VHD)

While each measure is a standard aggregate reporting statistic for travel demand model work and is helpful for comparing scenarios against each other, VHD was selected as the most meaningful statistic for this study because it directly measures traffic congestion. Specifically, it indicates the additional time spent on the network due to other traffic.

VHD is inversely related to user benefit; a reduction in VHD results in reduced travel time and decreased idle time, which saves money and lessens pollutants. Alternatively, VMT and VHT are not directly related to user benefit; while an increase in VMT or VHT does lead to increased travel and mobility, the additional travel also results in increased air pollution and promotes non-dense development patterns. Furthermore, changes in VMT and VHT are more beneficial to longer trips, which are typically regional in nature (especially along I-40 through the study area).

6.2 Evaluation Criteria

As noted in the first chapter, the purpose of this study is to evaluate the various proposed roadway projects and alternatives in the PTIA area. The evaluation of these projects will improve GUAMPO's decision-making by providing objective and comparative measures of project performance. This performance includes traffic statistics along with cost information, provided earlier in the report. The following section provides benefit/cost analysis information that provides insight into the return on investment for the different projects. Ultimately, this information is most useful for designing a project implementation plan intended to meet specific GUAMPO objectives.

6.3 Project Scenario Analysis

The model data and cost information were combined to create the following variables:

- Projects – Number of individual projects included in each scenario, ranging from one to twelve.
- Cost (Million) – Total cost of the projects included in each scenario, in millions of dollars.
- VHD Reduction – Difference in VHD between each scenario and the base scenario (2035 E+C network, no scenario projects).
- VHD Reduction/Project – Total VHD reduction per number of projects included in each scenario.
- VHD Reduction/Cost (Million) – Total VHD reduction per scenario cost.

Due to the large number of scenarios under evaluation, the initial screening of scenario performance involved the creation of Figures 18 through 22, which compare the scenario variables by highlighting different relationships.

Figure 18 compares the scenario cost with its corresponding VHD reduction. As shown on the figure, almost all scenarios result in a VHD reduction from the base case (2035 E+C: 15,047 VHD), with a maximum reduction of approximately 6,100 VHD.

Figure 18. Cost (Million) vs. VHD Reduction

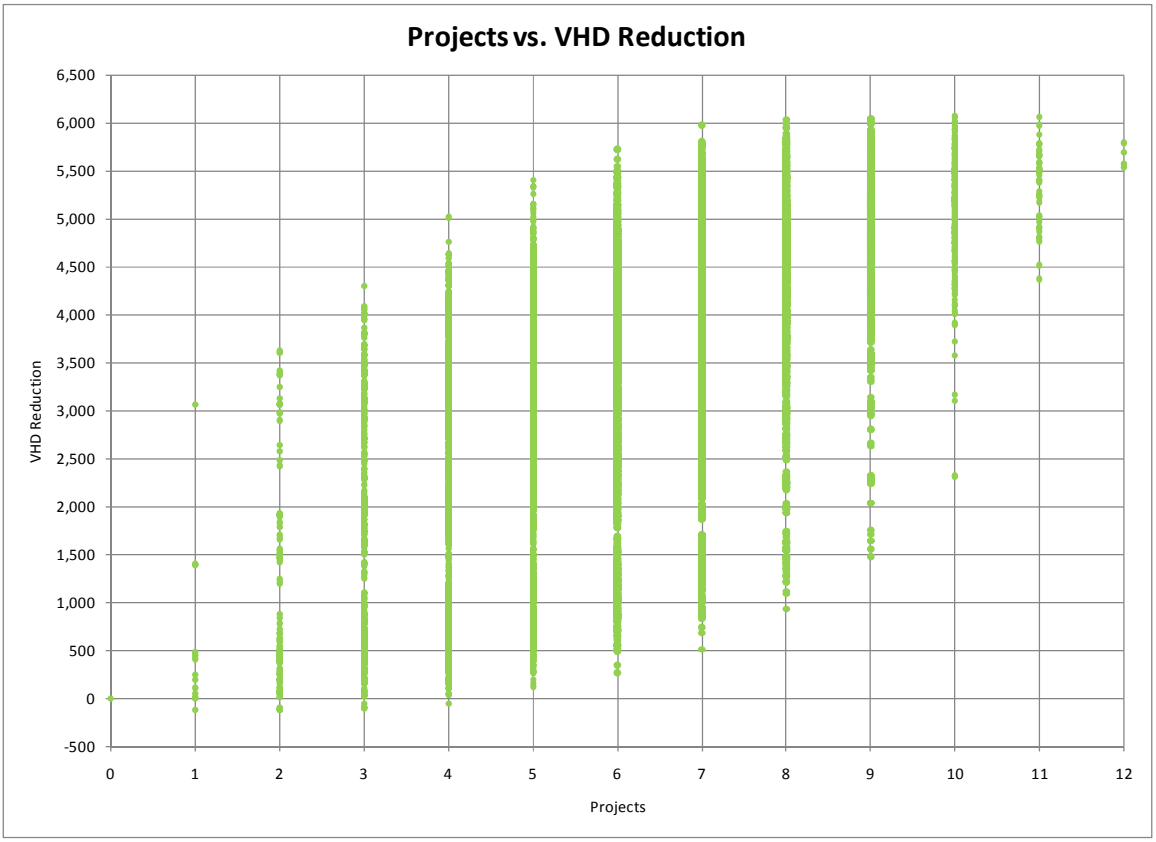
actually increase VHD (These scenarios include projects that may eliminate a bottleneck in one area, only to move it to another, more constrained location). The most interesting finding from this figure is the tradeoff between cost and VHD reduction.

While the general trend indicates increasing cost yields a higher VHD, there is a wide range of performance at each cost increment. For example, spending approximately $600 million can generate a VHD reduction ranging from approximately 2,200 to 5,000, depending on which specific projects are built. This result indicates that the combination of projects (especially complimentary projects such as the I-73 Connector and the Airport Connector) has more influence on VHD reduction than does the total cost of the scenario.

Figure 18 also begins to reveal the issue of diminishing returns -- a topic covered in more detail in the discussion of Figure 21. For example, doubling the infrastructure investment by adding a second $600 million in projects yields only 20% of the delay reduction obtained from the first $600 million investment (assuming that $600 million was optimally spent).

Figure 19 organizes results by comparing the number of projects in a scenario to the VHD reduction. The general trend indicates that the more projects a scenario has, the larger the VHD reduction. That being said, the specific combination of projects can result in drastically different VHD reduction levels. For example, scenarios with seven projects can result in VHD reductions between approximately 500 and 6,000. These results further confirm that the specific combination of projects is the most important predictor of VHD reduction, even more important than the number of projects.

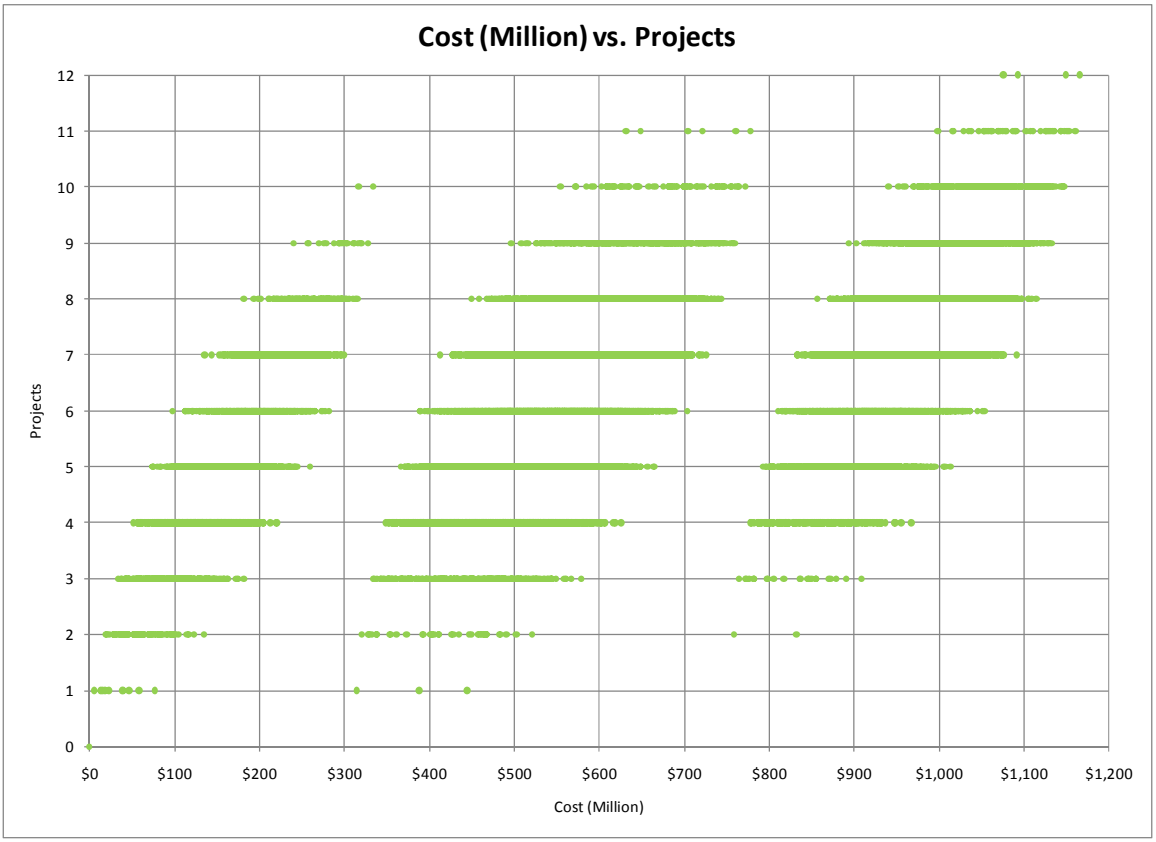
Figure 19. Projects vs. VHD Reduction



It should also be noted that the scenario yielding the highest VHD reduction (approximately 6,100) includes only ten projects. Adding an eleventh or twelfth project results in a lower VHD reduction, indicating that, while they may provide additional roadway capacity or routing options, some of these projects are redundant, especially when constructed with a host of other projects.

Figure 20 compares the cost of each scenario to the number of projects constructed. There is no clear relationship between the cost of a scenario and the number of projects. It may be expected that the number of projects in a scenario should increase with the total cost. This is not the case in the PTIA area due to huge cost differences between individual projects, specifically freeway projects versus local roadway projects. For example, spending approximately $440 million allows for a scenario that constructs only the I-40 widening project, while spending approximately $250 million allows for a scenario that constructs nine separate, smaller projects.

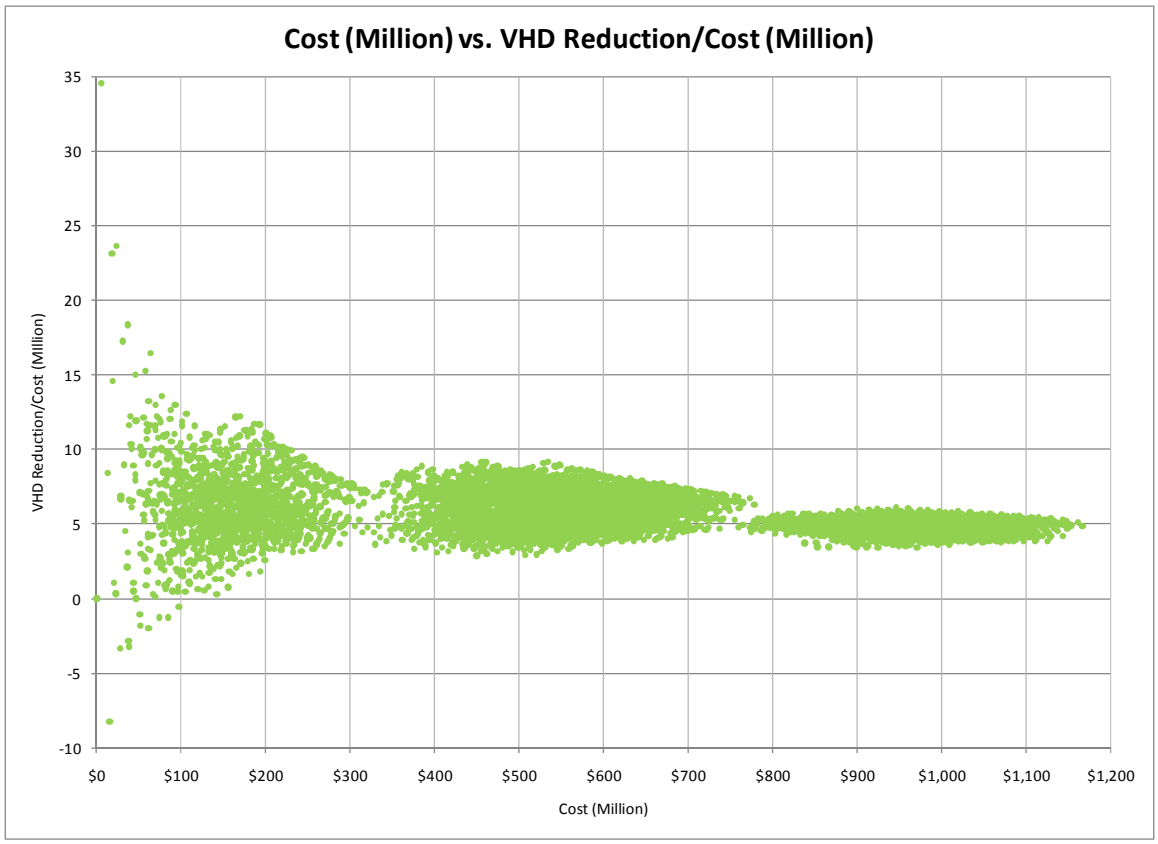
Figure 20. Cost (Million) vs. Projects



This provides additional proof that the specific combination of projects is important to scenario performance, particularly the resulting cost. A similar amount can be spent on different scenarios that construct one large project or multiple smaller projects. While the large project may yield the greatest reduction in VHD, the multiple smaller projects may still result in a substantial reduction in VHD while also addressing a host of secondary needs (local access, increased goods movement, etc).

Figure 21 compares scenario cost to VHD reduction/cost, which is essentially a measure of per dollar effectiveness (in terms of VHD reduction), for each additional dollar spent on a scenario. The general trend shows that the additional effectiveness of any dollar spent on a scenario converges around 5.0, as the total scenario cost increases. The real variation in VHD reduction/cost occurs between $0 and $300 million, which indicates some of the cheaper scenarios provide a greater VHD reduction/cost than more expensive scenarios. These scenarios primarily contain roadway widening projects, which are much less expensive than new freeway construction.

Figure 21. Cost (Million) vs. VHD Reduction/Cost (Million)

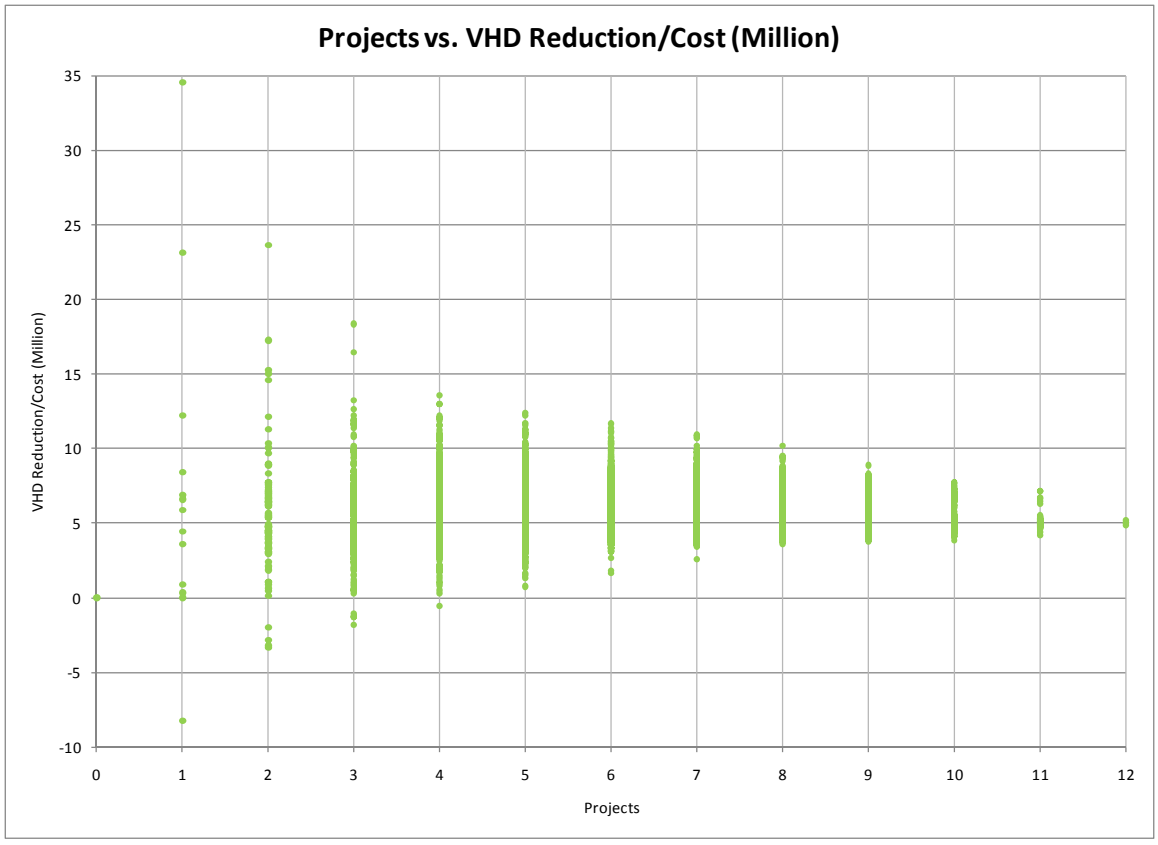


The general pattern in the figure shows that there are diminishing returns for each additional dollar spent on a given project scenario. Alternatively, there is greater VHD reduction/cost associated with the cheaper projects. This is important to acknowledge, due to the inherent risk associated with future activities, such as constructing roadway projects. In light of this, the future must be discounted because there is risk that some or all of the projects in a given scenario might not be built. History shows that money or other factors may limit the ultimate completion of all the projects.

Figure 22 compares the number of projects constructed to the corresponding VHD reduction/cost. The trend is similar to that of the previous figure, though this reveals that the top performing scenarios tend to have four or fewer projects. Additionally, the rate of return appears to flatten between seven and ten projects, and then decline further with eleven or twelve projects. Similar to the previous comments, the combination of projects

matters to the performance of a scenario. In this case, scenarios that contain more than seven projects do not provide additional VHD reduction in proportion to their additional cost.

Figure 22. Projects vs. VHD Reduction/Cost (Million)



6.4 Implementation Plan Strategies

As noted above, scenario performance is directly related to specific project combinations. While there is no prescribed method for determining the best sequence for building the projects under evaluation, there are three distinct implementation plan strategies for the PTIA area:

- Minimize cost
- Maximize VHD reduction
- Maximize VHD reduction/cost

Each strategy is viable and provides a valid basis for decision-making, though the timing and magnitude of VHD reduction and costs differ.

6.5 Minimize Cost Strategy

As shown in Table 6, this implementation plan focuses on building projects in order of increasing cost. This strategy calls for the construction of local road projects before any new freeway projects are built. This strategy is favorable from a financial standpoint, because it allows for the construction of six projects while spending less than $100 million. However, this strategy does not produce a 1,000 VHD reduction (roughly 18% of the maximum) until the seventh project.

Table 6. Minimize Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pleasant Ridge Road Widening	275	$ 18.8	14.6
3	Pleasant Ridge Road Relocation	153	$ 33.7	4.5
4	Pegg/Thatcher Street Connection	518	$ 51.6	10.0
5	Sandy Ridge Road Extension (North)	569	$ 74.3	7.7
6	Airport Connector	758	$ 97.4	7.8
7	Bryan Boulevard Loop	1,015	$ 135.2	7.5
8	I-40 Connector	1,472	$ 181.6	8.1
9	NC 68 Widening	1,559	$ 239.7	6.5
10	I-73 Connector	2,319	$ 316.5	7.3
11	I-73/I-74 Connector (Arterial)	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

6.6 Maximize VHD Reduction Strategy

As shown in Table 7, this implementation plan focuses on building projects in order of increasing VHD reduction. This strategy calls for the construction of new freeway projects before constructing any local road projects. This strategy is favorable from a traffic standpoint, because it produces a 3,059 VHD reduction (roughly 51% of the maximum) with the first project. However, this strategy frontloads the costs and surpasses $1,000 million with the construction of the seventh project. It should be noted that the "maximize VHD reduction" strategy project sequence is almost a mirror image of the "minimize cost" strategy.

Table 7. Maximize VHD Reduction Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	I-40 Widening	3,059	$ 444.1	6.9
2	I-73/I-74 Connector (Freeway)	3,602	$ 832.1	4.3
3	Airport Connector	4,296	$ 855.2	5.0
4	I-73 Connector	5,016	$ 932.1	5.4
5	I-40 Connector	5,406	$ 978.4	5.5
6	Pegg/Thatcher Street Connection	5,725	$ 996.3	5.7
7	Sandy Ridge Road Extension (North)	5,977	$ 1,019.0	5.9
8	Bryan Boulevard Loop	6,031	$ 1,056.8	5.7
9	NC 68 Widening	6,050	$ 1,114.9	5.4
10	Pleasant Ridge Road Relocation	6,078	$ 1,129.8	5.4
11	Pleasant Ridge Road Widening	6,060	$ 1,143.0	5.3
12	Sandy Ridge Road Widening	5,790	$ 1,148.6	5.0

6.7 Maximize VHD Reduction/Cost Strategy

As shown in Table 8, this implementation plan focuses on building projects in order of greatest incremental VHD reduction/cost, or the most effective projects per dollar spent. This strategy calls for the construction of local roadways before new freeway projects. This strategy is favorable from a VHD reduction/cost standpoint, because it produces a 1,250 VHD reduction (roughly 22% of the maximum) with the construction of the fifth project, for a cost of only $151.2 million. This strategy backloads the costs and requires an increment of $444.1 million between the tenth and eleventh projects. It should be noted that the "maximize VHD reduction/cost" strategy project sequence is very similar to the "minimize cost" strategy.

Table 8. Maximize VHD Reduction/Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pegg/Thatcher Street Connection	553	$ 23.4	23.6
3	Pleasant Ridge Road Widening	673	$ 36.7	18.3
4	Bryan Boulevard Loop	899	$ 74.4	12.1
5	I-73 Connector	1,250	$ 151.2	8.3
6	Pleasant Ridge Road Relocation	1,328	$ 166.1	8.0
7	Airport Connector	1,328	$ 189.2	7.0
8	I-40 Connector	2,209	$ 235.6	9.4
9	Sandy Ridge Road Extension (North)	2,299	$ 258.4	8.9
10	I-73/I-74 Connector (Arterial)	4,440	$ 573.2	7.7
11	NC 68 Widening	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

6.8 Comparison of Strategies

Figures 23 through 27 provide visual representations of the performance of the three implementation plan strategies. All three strategies perform well, especially when compared to the entire set of project combinations evaluated. While no single strategy clearly stands out as preferred, the "maximize VHD reduction/cost" strategy blends both the "minimize cost" and "maximize VHD reduction" strategies together.

Ultimately, this balance of VHD reduction and cost performance is a very reasonable strategy, and if pursued would be defendable from a cost standpoint, while also resulting in traffic improvements in the PTIA area. Additionally, the "maximize VHD reduction/cost" strategy is best for minimizing future risk. While all three strategies have similar VHD reduction at the end of the implementation plan (if all twelve projects are constructed and is considered a complete system), the "maximize VHD reduction/cost" strategy is a conservative approach that incrementally builds the best returning project out of all remaining available projects.

Since funding or other factors may halt ultimate completion of any implementation plan, the "maximize VHD reduction/cost" strategy provides interim systems that work – projects constructed in the early stages of the implementation plan are not dependent on the construction of other, future projects to realize the full value of earlier constructed projects. Therefore, a reasonable strategy is one that constructs a system that works well during all interim stages, since the ultimate completion of the implementation plan is an unknown variable that could be delayed, altered, or never fully realized.

Figure 23. Cost (Million) vs. VHD Reduction

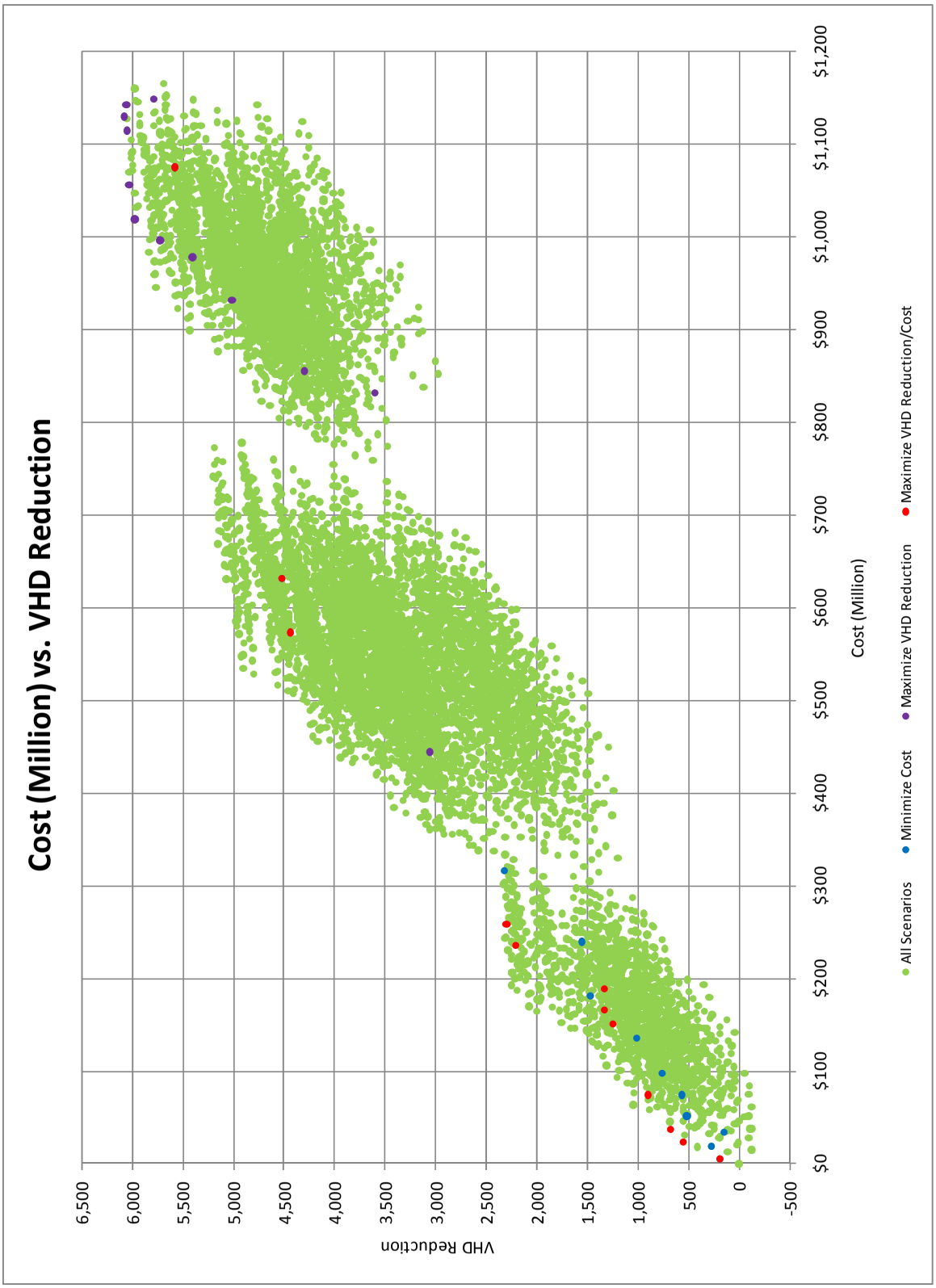


Figure 24. Projects vs. VHD Reduction

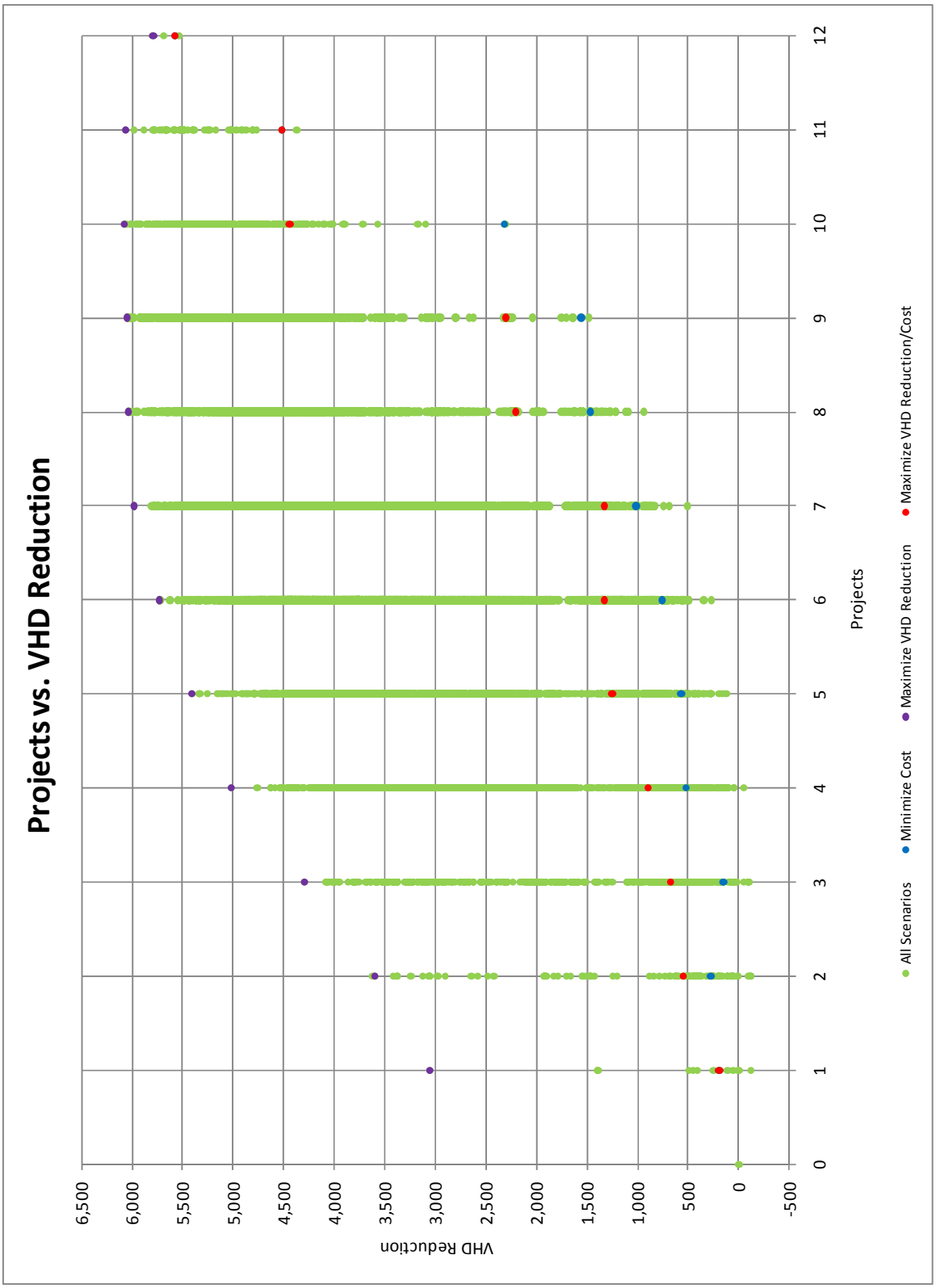


Figure 25. Cost (Million) vs. Projects

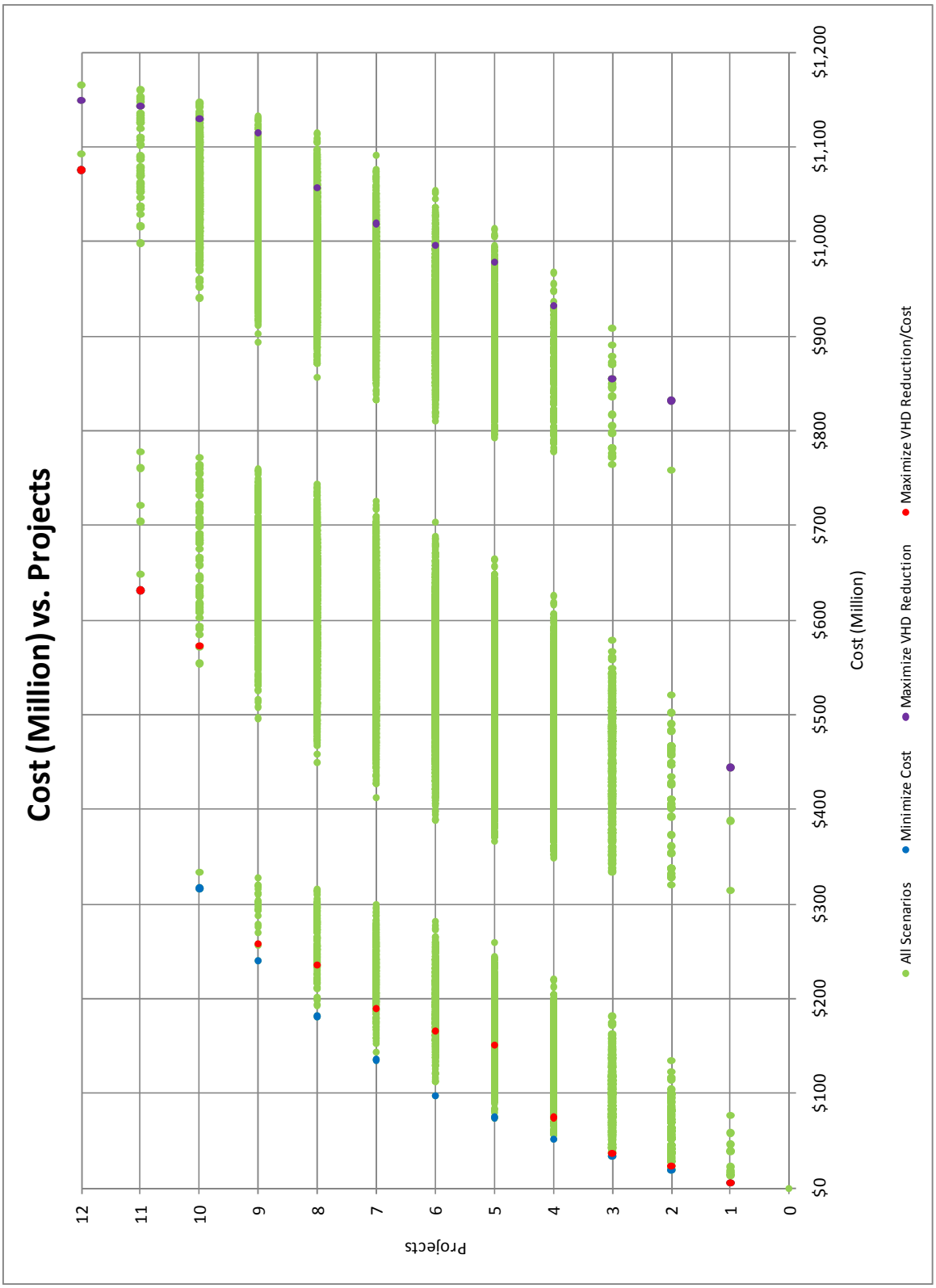


Figure 26. Cost (Million) vs. VHD Reduction/Cost (Million)

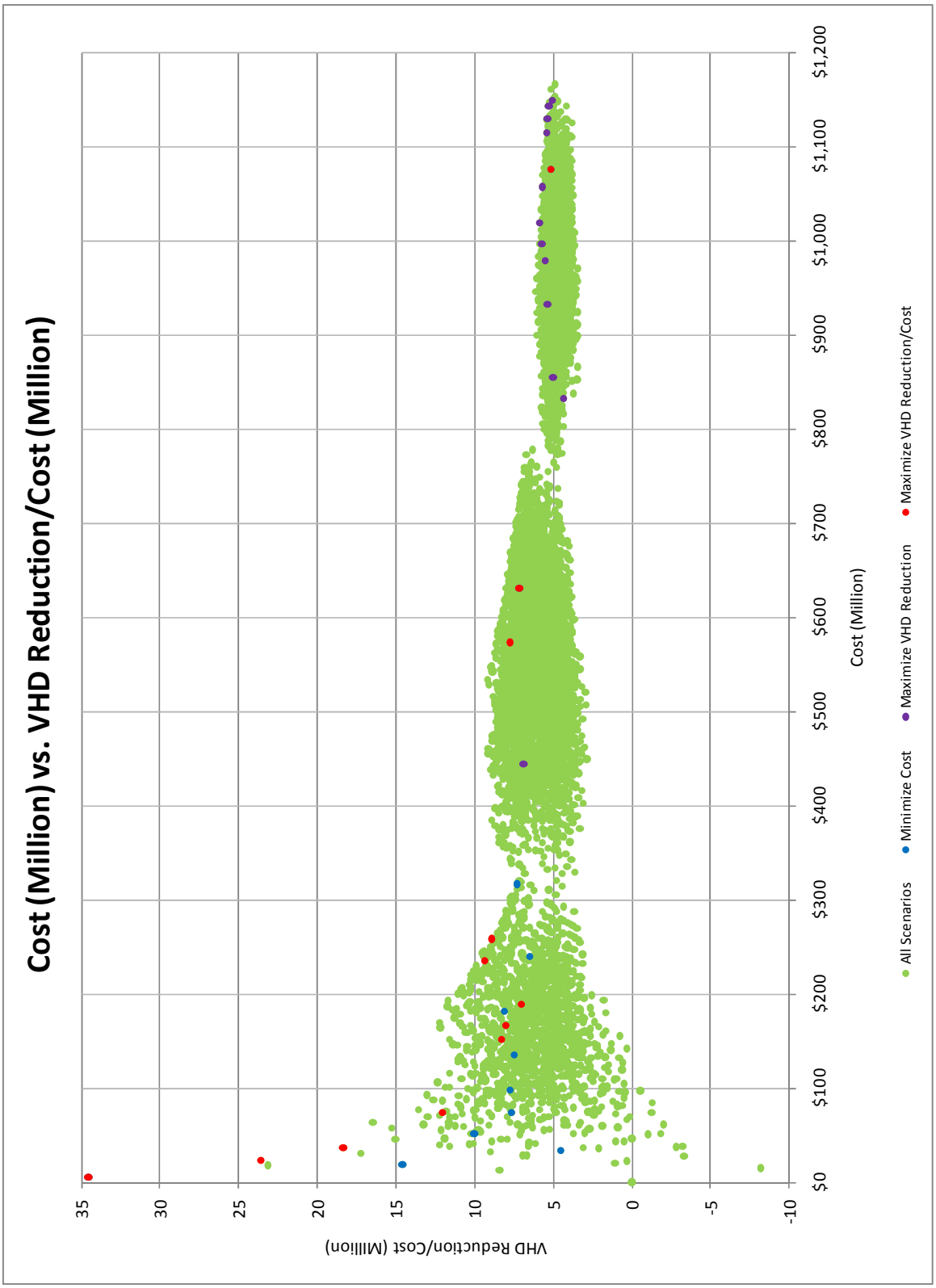
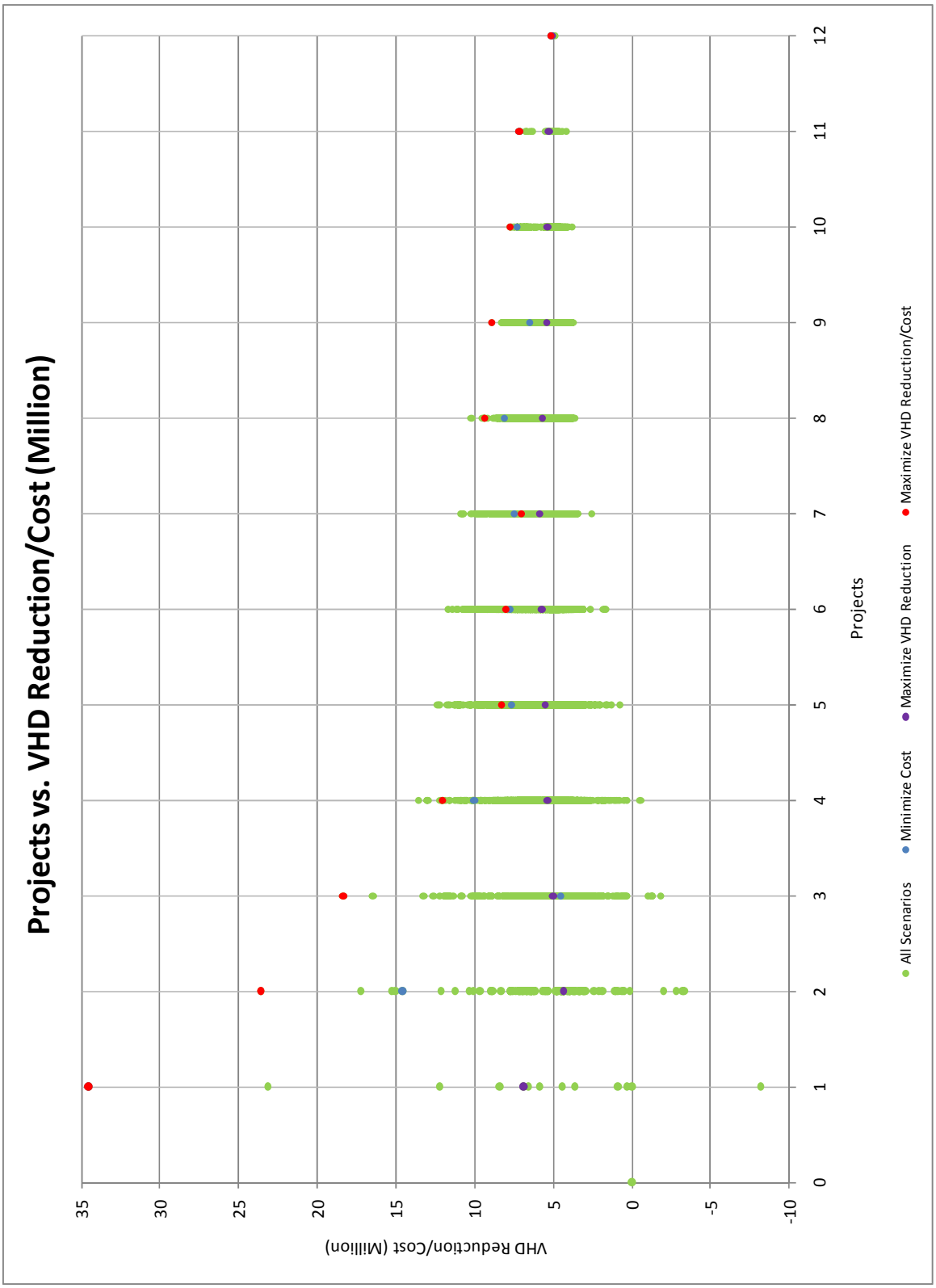


Figure 27. Projects vs. VHD Reduction/Cost (Million)



6.9 Notable Results

During the evaluation of the project scenarios and the implementation plan strategies, the following notable results became clear:

Sandy Ridge Road Widening

- Enhances Market Street widening project.
- Increases capacity parallel to I-40 by improving connectivity and access to alternate routes.
- Provides alternative access to the airport from the west and south.

Pegg/Thatcher Street Connection

- Driven primarily by land use development.
- Does not provide very equitable north-south capacity enhancements.

Sandy Ridge Road Extension

- East extension is not viable once I-73 Connector is built, due to loss of access to PTIA via Bryan Boulevard.
- North extension is viable only after the Airport Connector is built.
- A development driven collector extension could be beneficial, though no specific alternative was evaluated during the study.

NC 68 Widening

- Enhances Market Street widening project.
- Increases capacity parallel to I-73.
- Provides alternative access to the airport from the north, west, and south.

Pleasant Ridge Road Widening

- Enhances Market Street widening project.

- Reduces the need for a Sandy Ridge Road extension by providing a similar function when combined with widenings of Sandy Ridge Road and West Market Street.
- Provides alternative access to the airport from the west and south.
- Improves local access.

I-73 Connector

- Duplicates existing roadways that perform well today.
- Provides justification for Airport Connector.

Pleasant Ridge Relocation

- Warranted only after I-73 Connector and Airport Connector are built.
- Enhances local access.

I-73/74 Connector

- Arterial and Freeway options provide similar traffic benefits.
- Justified only after construction of the Airport Connector and/or Sandy Ridge Road Extension (North) and/or I-40 Connector.
- Will require additional improvements to local facilities serving the project.

I-40 Connector

- Traffic volumes and resulting benefits from this project are closely interrelated with other project decisions. The most significant interactions are associated with the widening of I-40, since these two projects share a substantial travel market. Combined with the Airport Connector and several road widening projects, the I-40 Connector could shift enough traffic off of I-40 to reduce or eliminate widen the segment between NC 68 and I-40 Bus. Conversely, if I-40 were to be widened, volumes on the I-40 Connector would be lower.

Airport Connector

- Arterial and Freeway options provide similar traffic benefits.

- Not justified until I-73/I-74 Connector, I-73 Connector, or I-40 Connector (or some combination) is built.

I-73 Connector Loop Roads

- Important for local access.
- Not justified until I-73 Connector and Airport Connector are built.

I-40 Widening

- Greatest benefit and greatest cost (as an individual project). However, some benefits in the study area (especially along I-40 between I-40 Bus and NC 68) can be obtained from other projects that shift traffic off of I-40. For example, building the I-40 Connector and the Airport Connector (combined with some other road widening) substantially lowers traffic on this portion of I-40, and could delay or eliminate the need for widening. On the other hand, completing the widening of I-40 could reduce the utility or demand for some of these (or other) projects.
- Difficult to construct while maintaining existing traffic patterns.

6.10 Other Considerations

The focus of this study involved the benchmarking and evaluation of project scenarios using traffic and cost information. While these two components are important factors influencing the selection and construction of roadway projects, they are by no means the only factors decision makers should consider. The following factors should be considered in concert with the results of this study:

- Local accessibility
- Changes in regional traffic patterns
- Goods movement
- Roadway network impact on development patterns
- Travel time changes to PTIA
- Enhancements to alternative modes

Greensboro Airport Area Modeling Study

December 2009

Prepared for the

Greensboro Urban Area

Metropolitan Planning Organization

MARTIN
ALEXIOU
BRYSON

Inside Front Cover

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Table of Contents

1 Executive Summary

1.1 Purpose

The purpose of the analysis is to revaluate the projects in the Piedmont Triad International Airport (PTIA) area. There are currently multiple combinations of twelve separate projects that could be constructed in the PTIA area. The technical evaluation of cumulative conditions in the PTIA area will support Greensboro Urban Area Metropolitan Planning Organization (GUAMPO) transportation system planning decisions. It will ensure that all previously identified project needs still exist and that the various proposed roadways in the area will meet these needs.

1.2 Project Scenario Analysis

The projects under consideration in the PTIA area were evaluated with the following travel demand model data and cost information:

- Projects – Number of individual projects included in each scenario, ranging from one to twelve.
- Cost (Million) – Total cost of the projects included in each scenario, in millions of dollars.
- VHD (Vehicle Hours of Delay) Reduction – Difference in VHD between each scenario and the base scenario (2035 E+C network, no scenario projects).
- VHD Reduction/Project – Total VHD reduction per number of projects included in each scenario.
- VHD Reduction/Cost (Million) – Total VHD reduction per scenario cost.

The above data was used to develop three implementation plan strategies for constructing the twelve projects.

1.3 Preferred Implementation Plan Strategy

As shown in Table 8, this implementation plan focuses on building projects in order of greatest incremental VHD reduction/cost, or the most effective projects per dollar spent. This strategy calls for the construction of local roadways before new freeway projects. This strategy is favorable from a VHD reduction/cost standpoint, because it produces a 1,250 VHD reduction (roughly 22% of the maximum) with the construction of the fifth project, for a cost of only $151.2 million. This strategy backloads the costs and requires an increment of $444.1 million between the tenth and eleventh projects. It should be noted that the "maximize VHD reduction/cost" strategy project sequence is very similar to the "minimize cost" strategy.

Table 1. Maximize VHD Reduction/Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pegg/Thatcher Street Connection	553	$ 23.4	23.6
3	Pleasant Ridge Road Widening	673	$ 36.7	18.3
4	Bryan Boulevard Loop	899	$ 74.4	12.1
5	I-73 Connector	1,250	$ 151.2	8.3
6	Pleasant Ridge Road Relocation	1,328	$ 166.1	8.0
7	Airport Connector	1,328	$ 189.2	7.0
8	I-40 Connector	2,209	$ 235.6	9.4
9	Sandy Ridge Road Extension (North)	2,299	$ 258.4	8.9
10	I-73/I-74 Connector (Arterial)	4,440	$ 573.2	7.7
11	NC 68 Widening	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

1.4 Comparison of Strategies

Ultimately, the balance of VHD reduction and cost performance is a very reasonable strategy, and if pursued would be defendable from a cost standpoint, while also resulting in traffic improvements in the PTIA area. Additionally, the "maximize VHD reduction/cost" strategy is best for minimizing future risk. While all three strategies have similar VHD reduction at the end of the implementation plan (if all twelve projects are constructed and is considered a complete system), the "maximize VHD reduction/cost" strategy is a conservative approach that incrementally builds the best returning project out of all remaining available projects.

Since funding or other factors may halt ultimate completion of any implementation plan, the "maximize VHD reduction/cost" strategy provides interim systems that work – projects constructed in the early stages of the implementation plan are not dependent on the later construction of other projects to realize the full value of earlier constructed projects. Therefore, a reasonable strategy is one that provides a desirable outcome at each interim stages of implementation, since the completion of the ultimate plan as currently envisioned cannot be guaranteed, due to unforeseeable changes in funding, growth and development, construction schedules, programming priorities, and other conditions.

2 Introduction

The Greensboro Urban Area Thoroughfare Plan (GUATP) includes important conceptual roadways near Piedmont Triad International Airport (PTIA). Many of the roadways were recommended as a part of the 2004 Triad International Airport Area Transportation Study. Major roadways resulting from the study include: Airport Connector (I-73/ I-74 Connector), I-40 Connector, and the Sandy Ridge Extension. Both connectors are identified as freeways, while Sandy Ridge Extension is a major thoroughfare.

Since the release of the GUATP by the Greensboro Urban Area Metropolitan Planning Organization (GUAMPO), additional planning studies have been conducted, including the Heart of the Triad Plan and the 2035 GUAMPO Long Range Transportation Plan (LRTP). Additionally, land in and around PTIA has been identified for airport and private development. Finally, the economic landscape has greatly changed within the last year and there is a greater emphasis on cost performance of major infrastructure investment projects. As such, GUAMPO decided to revaluate the planned roadway network near PTIA to ensure that the proposed roadways are needed and cost-effective.

It should be noted that PTIA is currently conducting a study of the Airport Area including the evaluation of roadways serving the airport. However, recommendations from the PTIA study were not available before the completion of this report.

2.1 Background

The Airport Area Transportation Study was completed by NCDOT in cooperation with the Triad MPOs and Piedmont Authority for Regional Transportation (PART). The recommended roadways noted above where added to the Greensboro Urban Area Thoroughfare Plan. The study also recommended the deletion of proposed projects shown on the Greensboro Thoroughfare Plan; they included the Sandy Ridge Road Connector from Sandy Ridge Road to Pleasant Ridge Road. This project was recommended for deletion as it was determined that the connection would result in an unacceptable LOS on Pleasant Ridge Road.

The study also recommended the deletion of the Joseph M. Bryan Boulevard Extension from NC 68 to Pleasant Ridge Road. It was recommended for deletion because it was believed the cost outweighed the benefit. However, the MPO decided to retain the proposed extension of Joseph M. Bryan Boulevard to Pleasant Ridge Road.

2.2 Purpose

The purpose of the analysis is to revaluate the projects in the PTIA area, including I-73/I-74 Connector, I-40 Connector, and Sandy Ridge Road Extension. There are currently multiple combinations of twelve separate projects that could be constructed in the PTIA area. The technical evaluation of cumulative conditions in the PTIA area will support GUAMPO transportation system planning decisions and ensure that all previously identified project needs still exist and that the various proposed roadways in the area will meet these needs. Additionally, the modeling work completed for this project will be used in support of the Sandy Ridge Road Widening and Extension Feasibility Study, currently underway.

2.3 Study Area

The PTIA is located in Guilford County, close to the Forsyth County border, and is bounded by Joseph M. Bryan Boulevard to the north, W. Market Street to the south, I-73 to the east, and NC 68 to the west. PTIA is located approximately 9 miles from downtown Greensboro, 11 miles from downtown High Point, and 16 miles from downtown Winston-Salem.

The study area for this project includes portions of the Piedmont Triad Region, which encompasses the Greensboro, Winston-Salem/Forsyth, High Point, and Burlington-Graham MPOs. The Piedmont Triad Regional Travel Demand Model (PTR TDM) covers all of the MPO boundaries, though only a subarea of the total model, described as the PTIA area within this report, was utilized for detailed traffic analysis.

This study area was selected for purposes of traffic forecasting because the projects in the PTIA area have the potential to draw traffic from the local surface streets, which are often congested during the peak periods. The project study area covers a larger extent than the actual roadway improvement design limits because it is necessary to examine the regional effects of traffic diversion through the area. Figures 1 and 2 show the extents of the PTR TDM and the PTIA area (shown in black), respectively.

Figure 1. Piedmont Triad Regional Travel Demand Model Extents

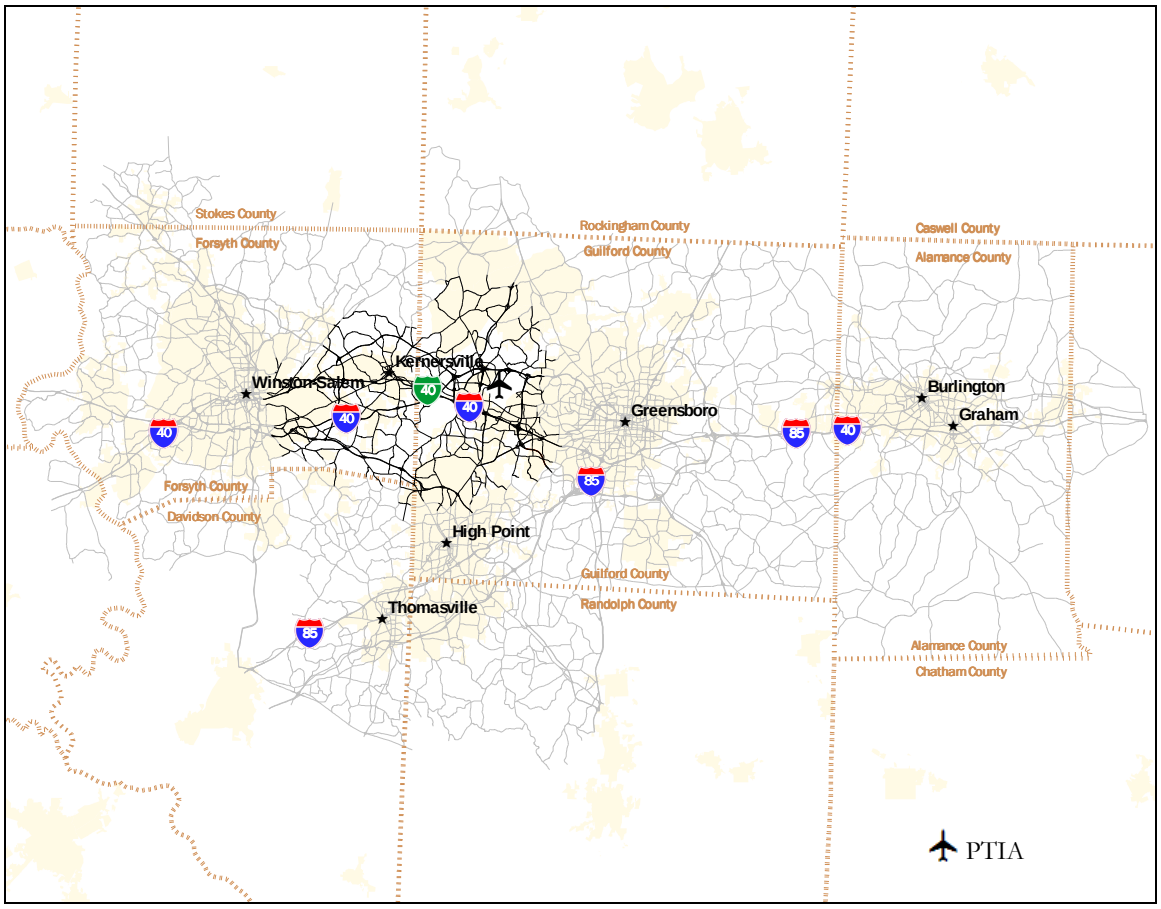
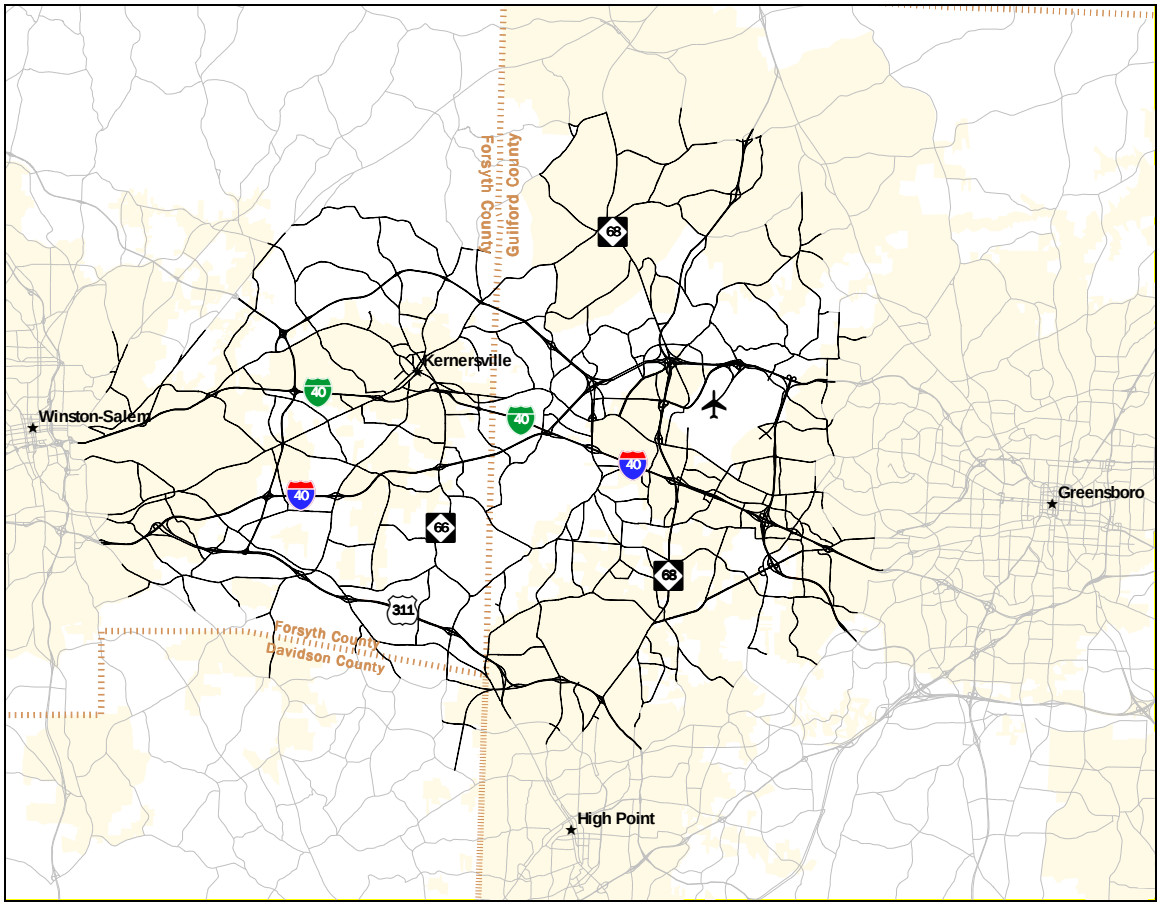


Figure 2. Piedmont Triad Airport Subarea Model Extents



2.4 Study Oversight

GUAMPO staff guided this study, though the following stakeholder group was consulted throughout the project:

- City of Greensboro Planning and Engineering
- City of High Point DOT
- City of Winston-Salem Planning and Engineering
- Town of Kernersville Public Works Department
- Piedmont Triad International Airport Authority
- Greensboro Metropolitan Planning Organization
- Winston-Salem Forsyth Metropolitan Planning Organization
- High Point Metropolitan Planning Organization
- Piedmont Authority for Regional Transportation
- North Carolina Department of Transportation

3 Projects Under Evaluation

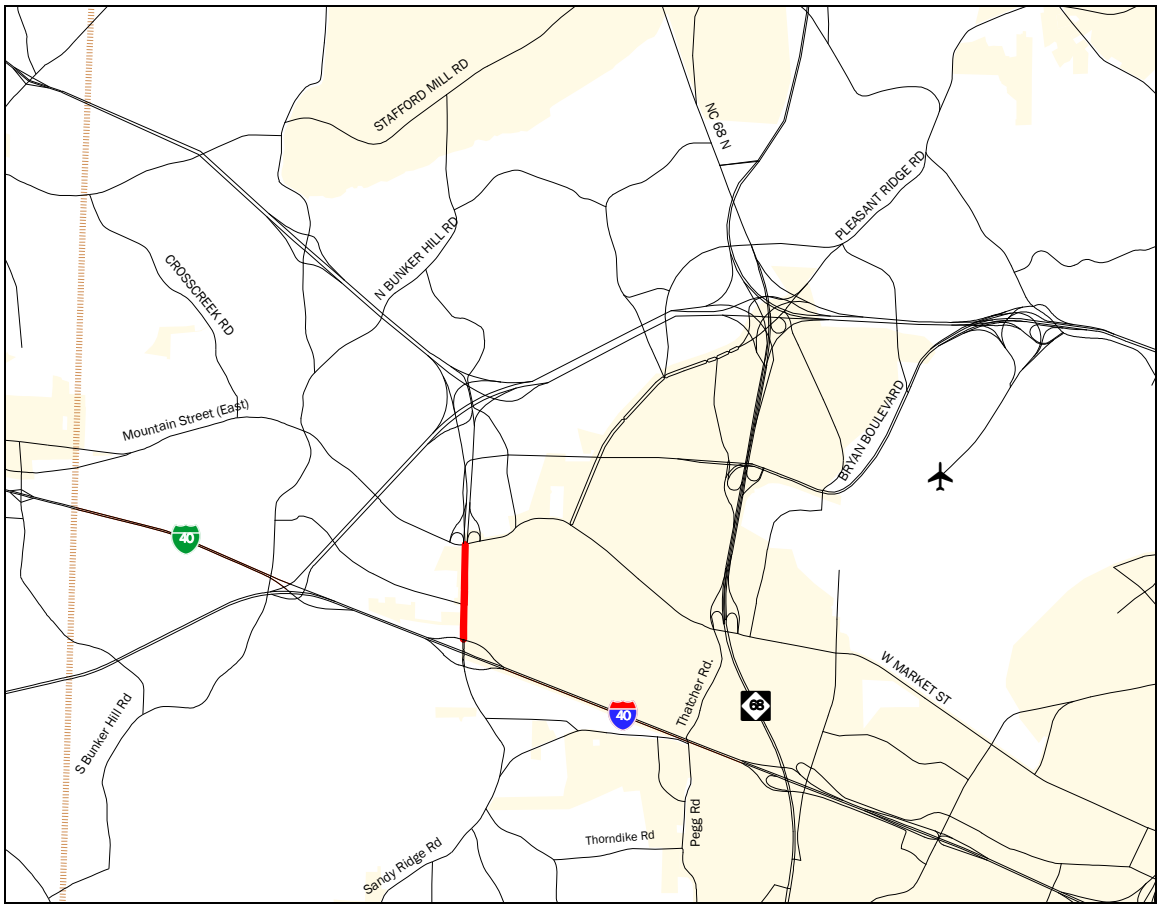
For this study, twelve projects are under consideration, some with multiple alternatives, as detailed in the following sections. Each project is designated by a letter (A-G) and a number (if there are multiple design options). Cost estimates (right of way and construction) for each project and design option are taken from the GUAMPO and WSMPO 2035 LRTPs, NCDOT feasibility studies, and NCDOT cost estimation sheets.

3.1 Sandy Ridge Road Widening

This project involves widening Sandy Ridge Road between I-40 and West Market Street. The existing Sandy Ridge Road is a collector road with one lane in each direction and no median. The proposed project widens this segment to two lanes in each direction with a median. The location of the Sandy Ridge Road widening project is shown in red on Figure 3.

- Project A1 – Existing Sandy Ridge Road – $0
- Project A2 – Widened Sandy Ridge Road – $5,554,852

Figure 3. Sandy Ridge Road Widening Project Extents

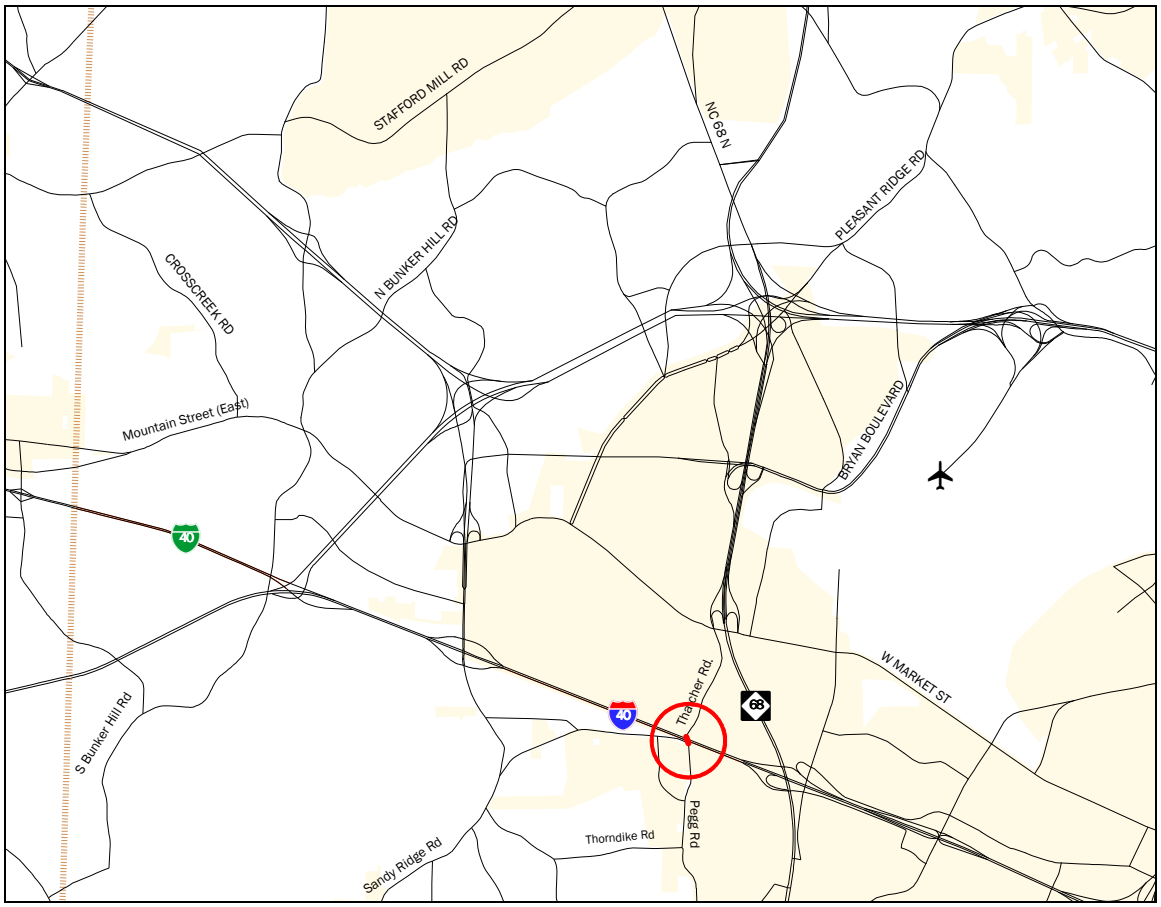


3.2 Pegg Road/Thatcher Road Connector

This project involves construction of a new facility to connect Pegg Road and Thatcher Road, which are currently separated by I-40. The proposed project adds a collector street with two lanes in each direction and a median that provides connectivity via a bridge over I-40. The location of the Pegg Road/Thatcher Road Connector project is shown in red on Figure 4.

- Project B – Pegg Road/Thatcher Road Connector – $17,855,910

Figure 4. Pegg Road/Thatcher Road Connector Project Extents

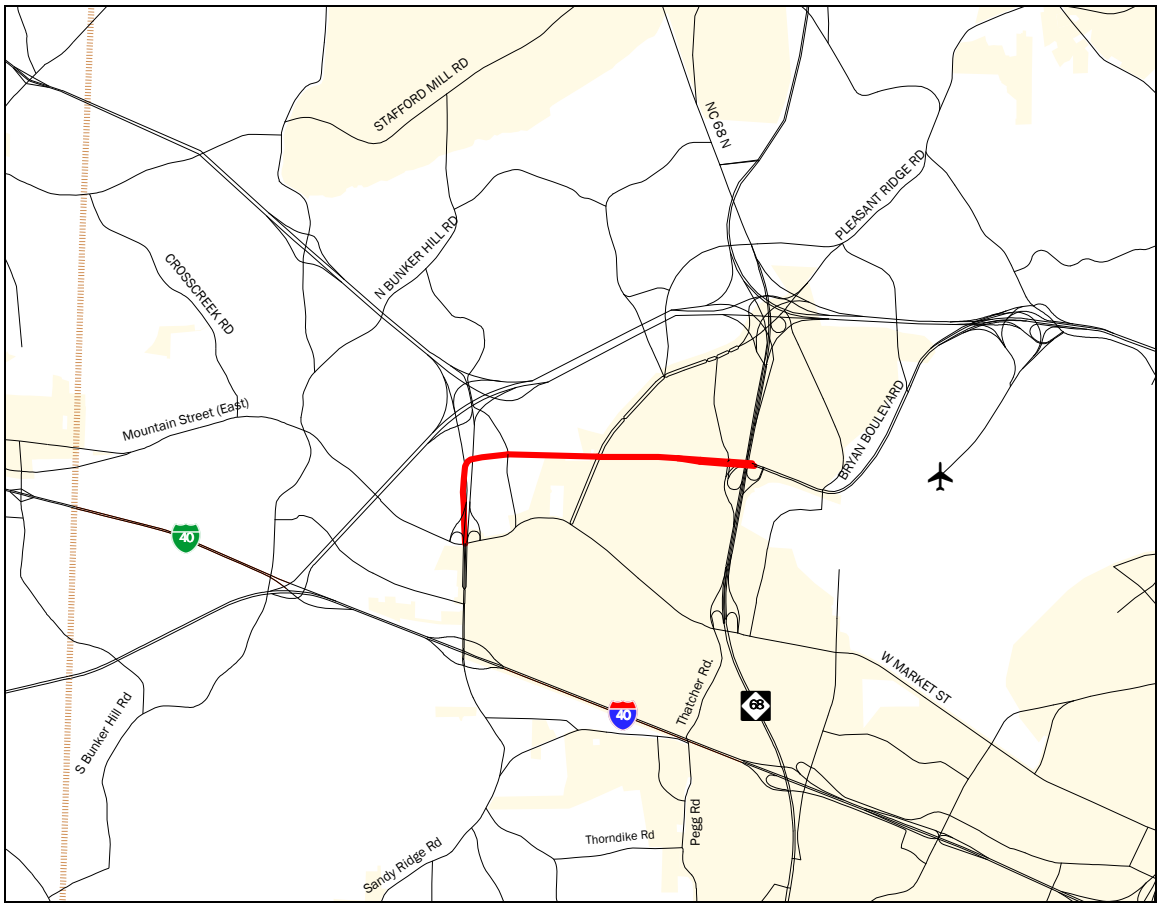


3.3 Sandy Ridge Road Extension

This project involves construction of a new facility to extend Sandy Ridge Road to either: 1) Bryan Boulevard (Eastern Extension) or 2) the proposed I-40 Connector (Northern Extension). The proposed Eastern Extension project is an arterial street with two lanes in each direction and a median that connects to Bryan Boulevard at an interchange with NC 68. The proposed Northern Extension project is a divided roadway with two lanes in each direction that connects to the proposed I-40 Connector at an interchange with the proposed I-73/I-74 and Airport Connectors. The location of the Sandy Ridge Road Extension projects are shown in red on Figures 5 (Eastern Extension) and 6 (Northern Extension).

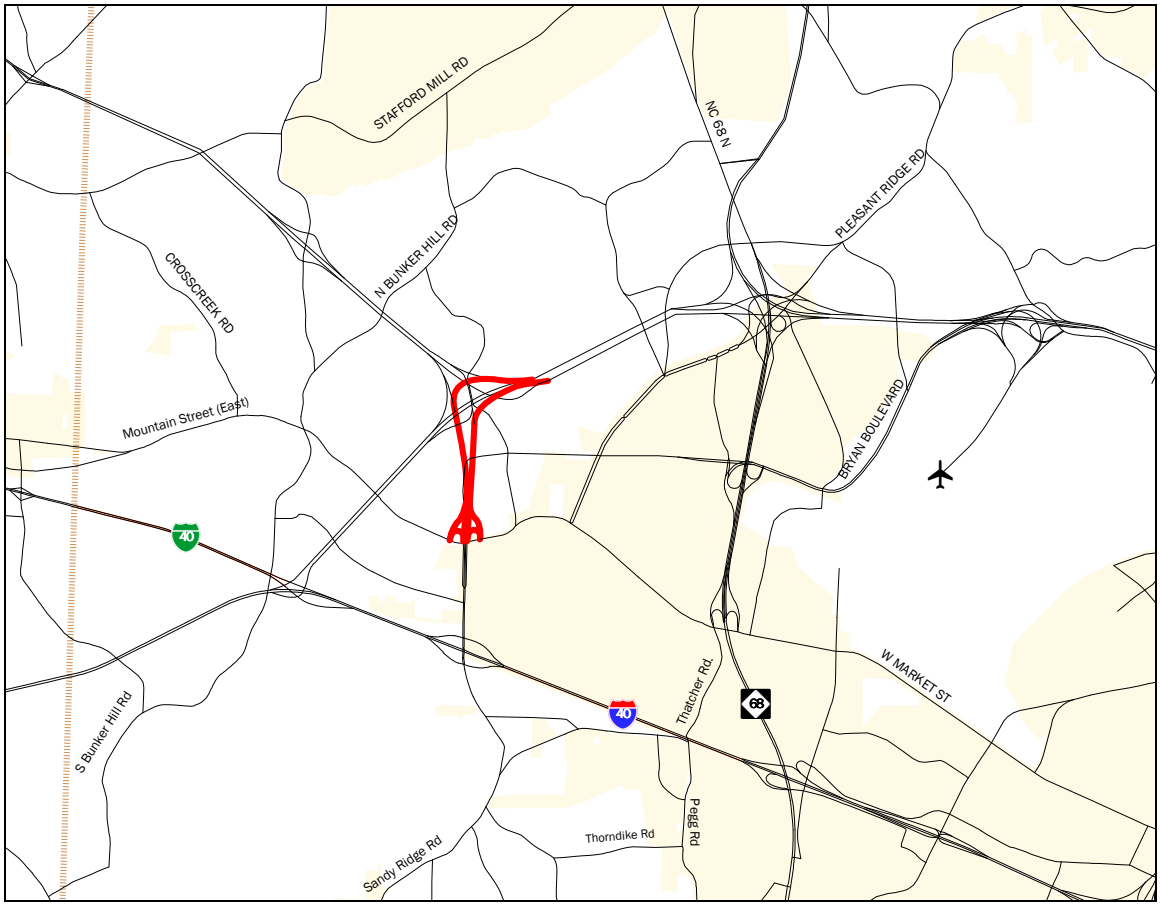
Modeling and analysis of both Sandy Ridge Road extension alternatives assumed a grade separation at West Market Street. An at-grade intersection could also be considered (either as an interim stage or as a final design), yielding substantial right-of way and construction savings.

Figure 5. Sandy Ridge Road Eastern Extension Project Extents



- Project C1 – Sandy Ridge Road Eastern Extension – $40,000,000
- Project C2 – Sandy Ridge Road Northern Extension – $22,768,800

Figure 6. Sandy Ridge Road Northern Extension Project Extents

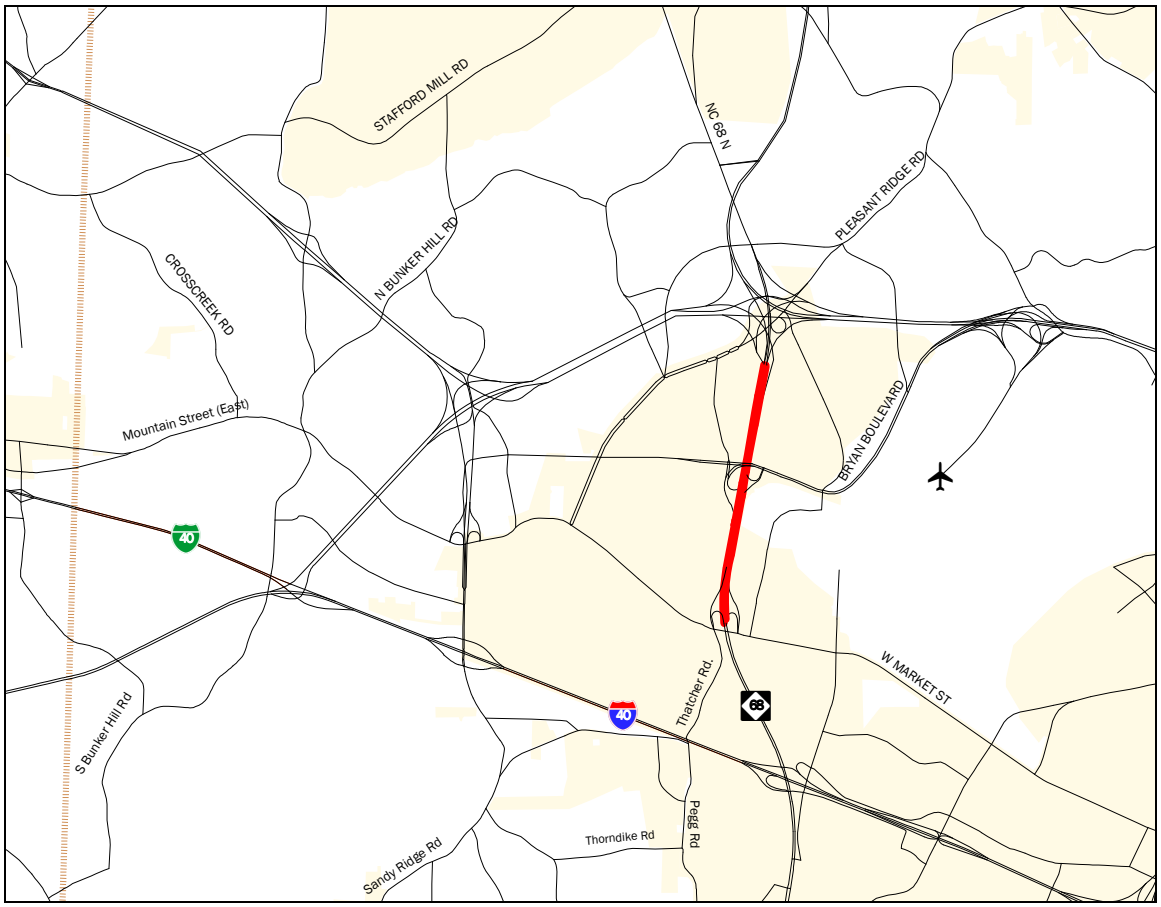


3.4 NC 68 Widening

This project involves widening a portion of NC 68 between West Market Street and Pleasant Ridge Road. The existing NC 68 is a divided highway with two lanes in each direction. The proposed project widens this section to four lanes in each direction. The location of the NC 68 widening project is shown in red on Figure 7.

- Project D1 – Existing NC 68 – $0
- Project D2 – Widened NC 68 – $58,114,585

Figure 7. NC 68 Widening Project Extents

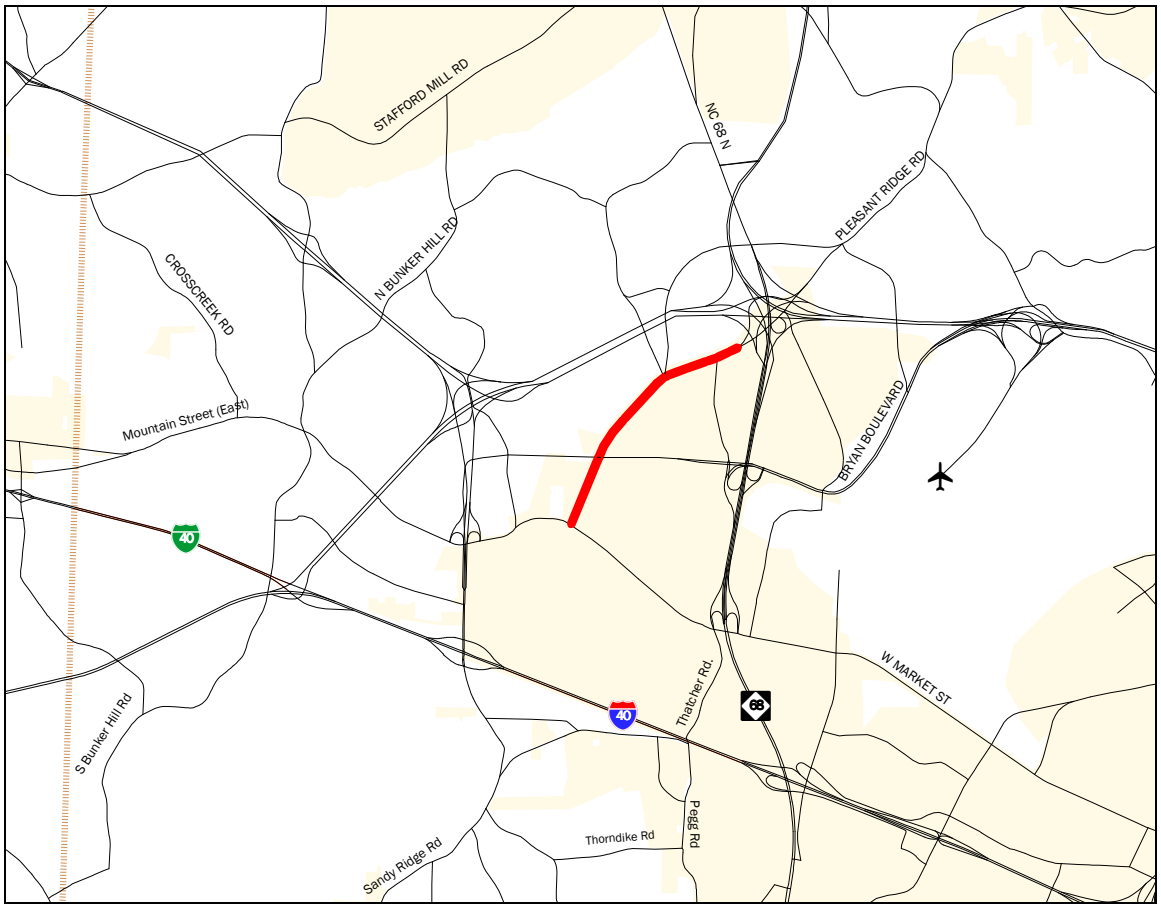


3.5 Pleasant Ridge Road Widening

This project involves widening a portion of Pleasant Ridge Road between West Market Street and Edgefield Road. The existing Pleasant Ridge Road is a rural road with one lane in each direction and no median. The proposed project widens this segment to two lanes in each direction with a median. The location of the Pleasant Ridge Road widening project is shown in red on Figure 8.

- Project E1 – Existing Pleasant Ridge Road – $0
- Project E2 – Widened Pleasant Ridge Road – $13,275,000

Figure 8. Pleasant Ridge Road Widening Project Extents

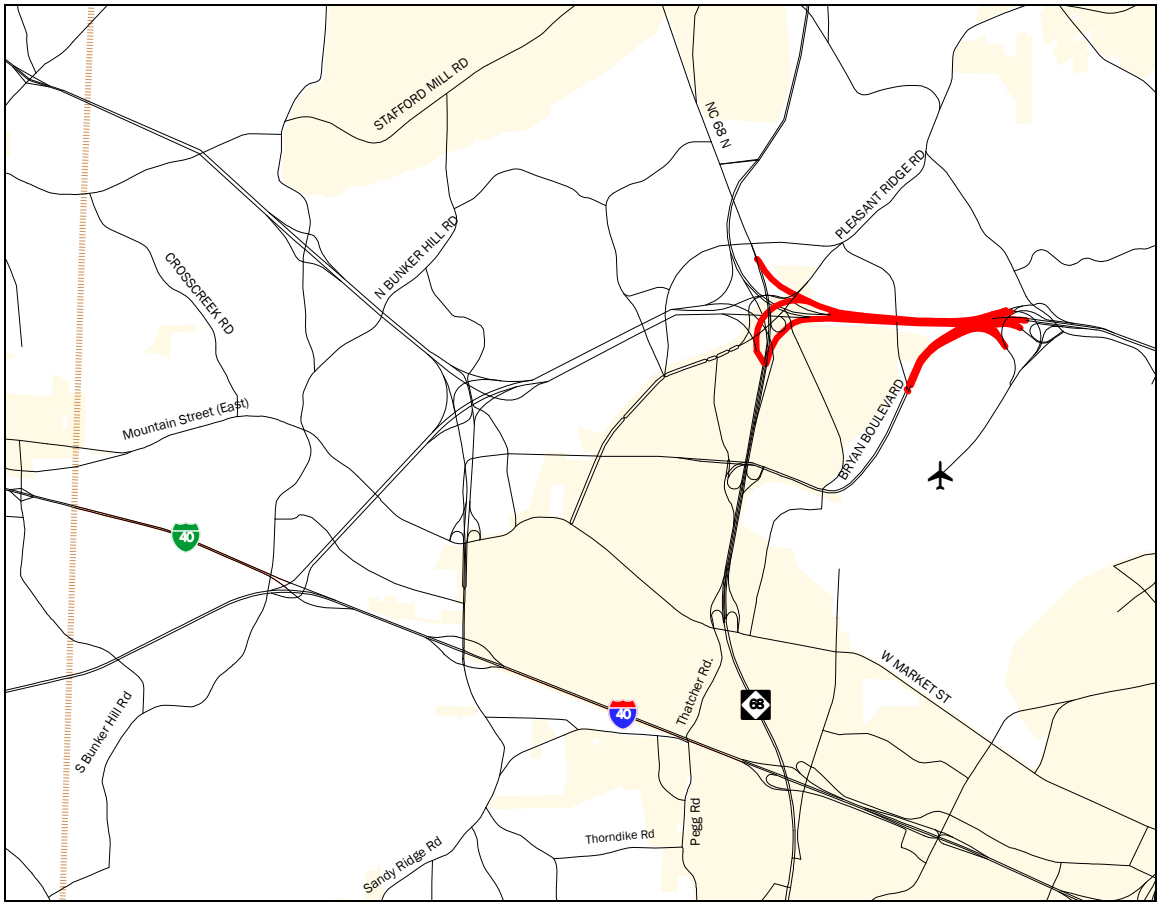


3.6 I-73 Connector

This project involves constructing a new facility between Joseph M. Bryan Boulevard and the future I-73. The proposed project is a divided freeway with two lanes in each direction. The proposed project also includes the removal of a portion of Bryan Boulevard between Caindale Drive and Old Oak Ridge Road. Additionally, the proposed project connects to the future I-73 at an interchange with NC 68 and the proposed Airport Connector. The location of the I-73 Connector project is shown in red on Figure 9.

- Project F1 – Existing Joseph M. Bryan Boulevard – $0
- Project F2 – I-73 Connector – $76,813,560

Figure 9. I-73 Connector Project Extents

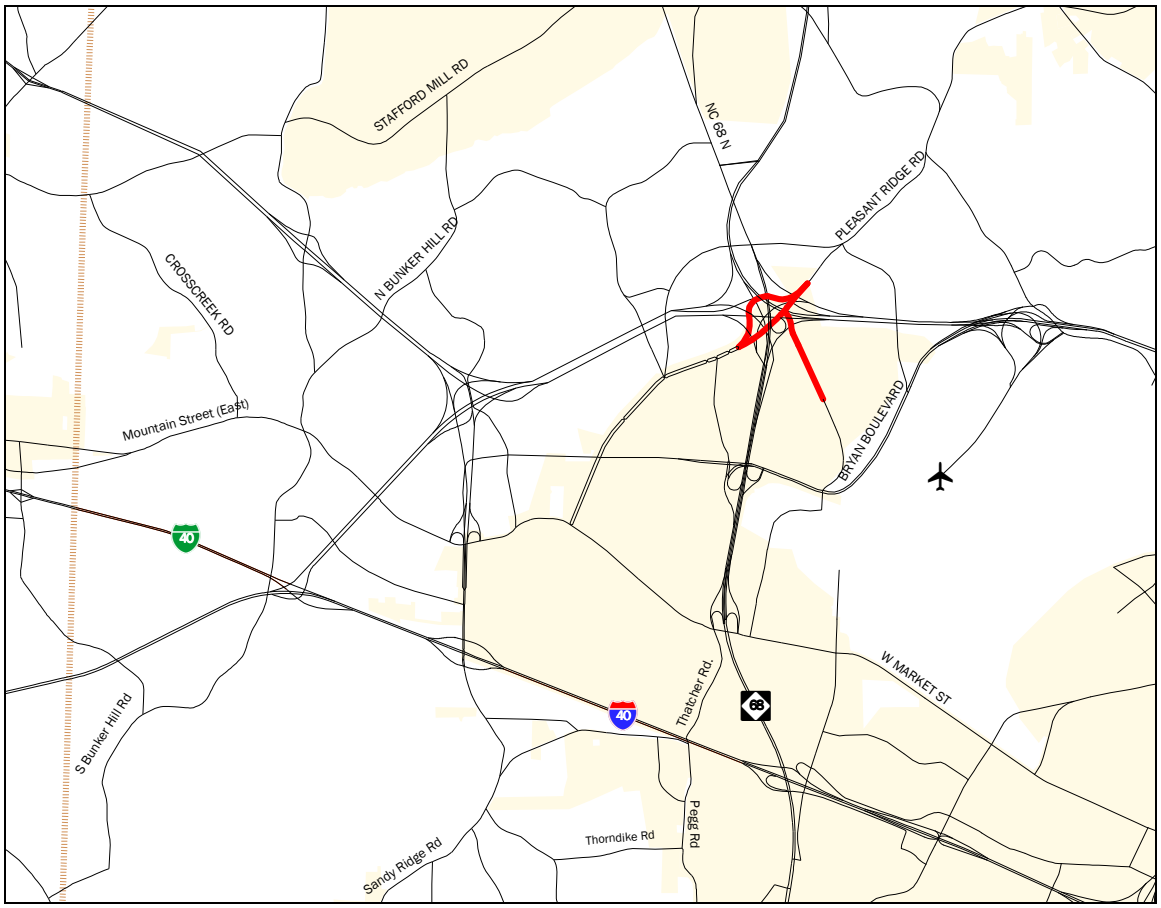


3.7 Pleasant Ridge Road Relocation

This project involves relocating a portion of Pleasant Ridge Road between Brigham Road and North Regional Road to make room for the future I-73/NC 68 interchange. The existing Pleasant Ridge Road is a rural road with one lane in each direction and no median. The proposed project widens the section to two lanes in each direction with a median located north of the current alignment. The project will have an at-grade intersection with NC 68. The location of the Pleasant Ridge Road relocation project is shown in red on Figure 10.

- Project G1 – Existing Pleasant Ridge Road – $0
- Project G2 – Relocated Pleasant Ridge Road – $14,869,268

Figure 10. Pleasant Ridge Road Relocation Project Extents



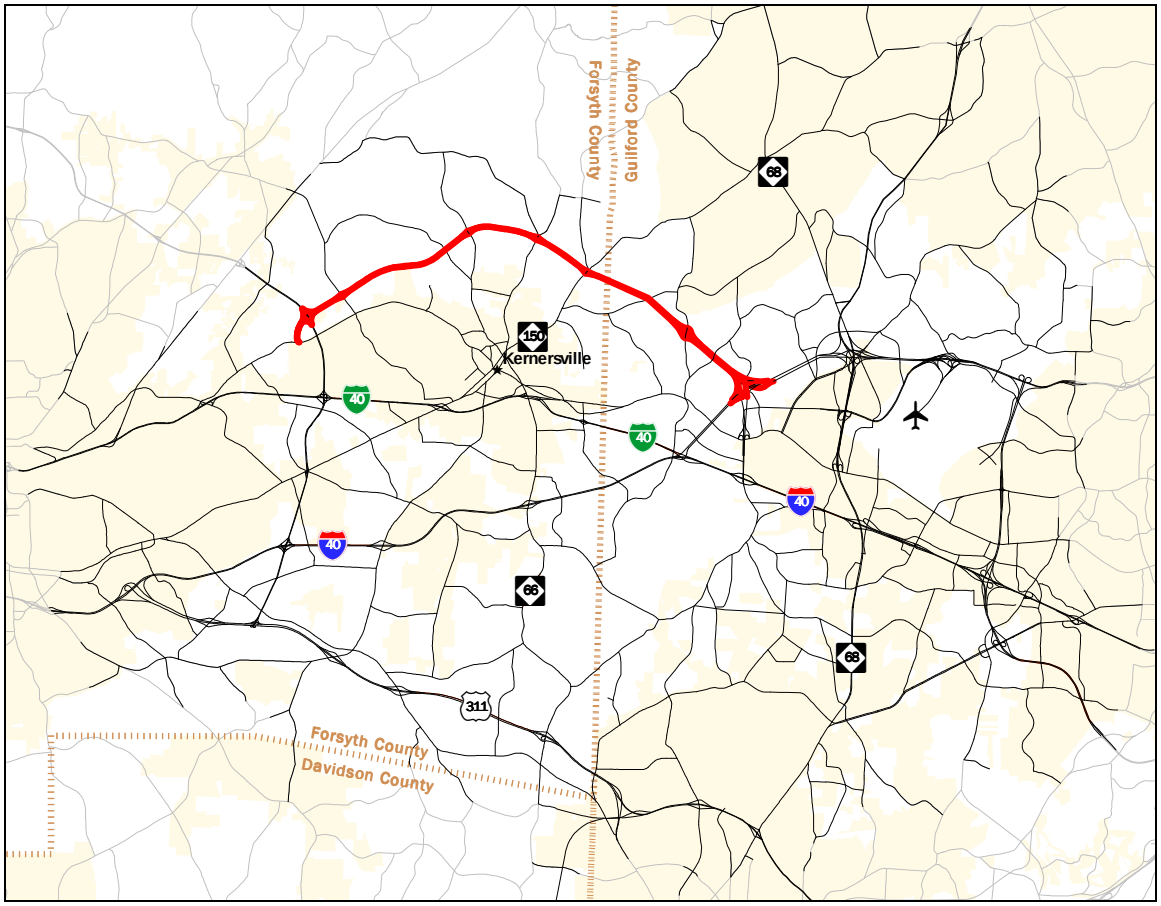
3.8 I-73/I-74 Connector

This project constructs a new facility, also known as the Kernersville Bypass, between West Mountain Street in Winston-Salem and the proposed Airport Connector. The proposed project has two options: 1) a divided freeway with two lanes in each direction or 2) an arterial street with two lanes in each direction and a median. The arterial version substitutes at-grade intersections for five of the seven interchanges in the freeway version, retaining the interchanges at the eastern and western termini.

This project connects to the proposed Airport Connector at an interchange with the proposed I-40 Connector and the Northern Sandy Ridge Road Extension. Note that the cost of this interchange is associated with the I-73/I-74 Connector project, not with the I-40 Connector, as assumed in the GUAMPO LRTP. This change was made to more accurately associate costs with the most appropriate project, given the segmentation of the Airport Connector in this analysis, and the variety of project combinations being assessed. The location of the I-73/I-74 Connector project is shown in red on Figure 11.

- Project H1 – Freeway I-73/I-74 Connector – $388,023,400
- Project H2 – Arterial I-73/I-74 Connector – $314,793,400

Figure 11. I-73/I-74 Connector Project Extents

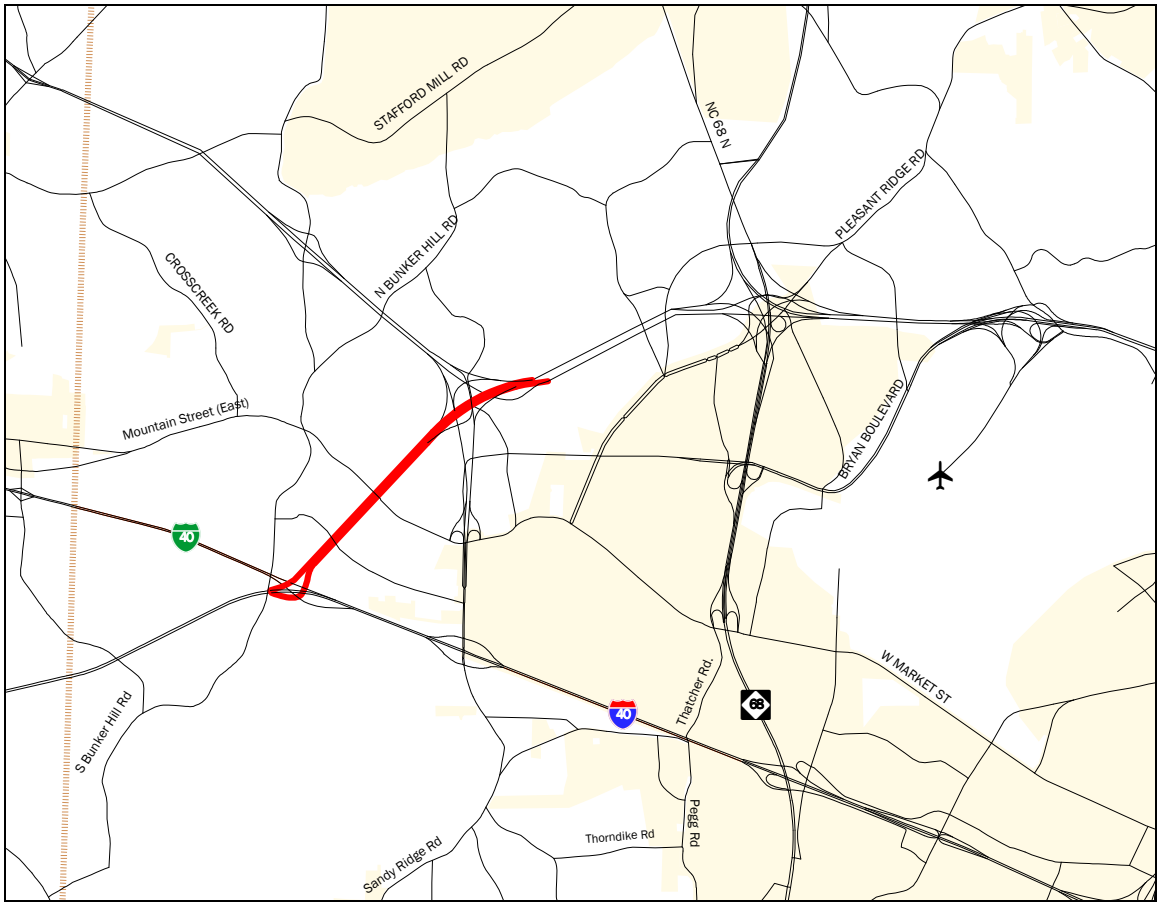


3.9 I-40 Connector

This project involves constructing a new facility between I-40 and the proposed Airport Connector. The proposed project is a divided freeway with two lanes in each direction and also includes the expansion of the I-40/Business I-40 interchange. The proposed project connects to the proposed Airport Connector at an interchange with the proposed I-73/I-74 Connector and Northern Sandy Ridge Road Extension. Note that while the GUAMPO LRTP attributes the cost of this interchange to the I-40 Connector, this analysis associates the cost of the interchange with the I-73/I-74 Connector project. Given the segmentation of the Airport Connector in this analysis, and the variety of project combinations being assessed, this change appears to more accurately associate costs with the most appropriate project. The location of the I-40 Connector project is shown in red on Figure 12.

- Project I – I-40 Connector – $46,354,000

Figure 12. I-40 Connector Project Extents

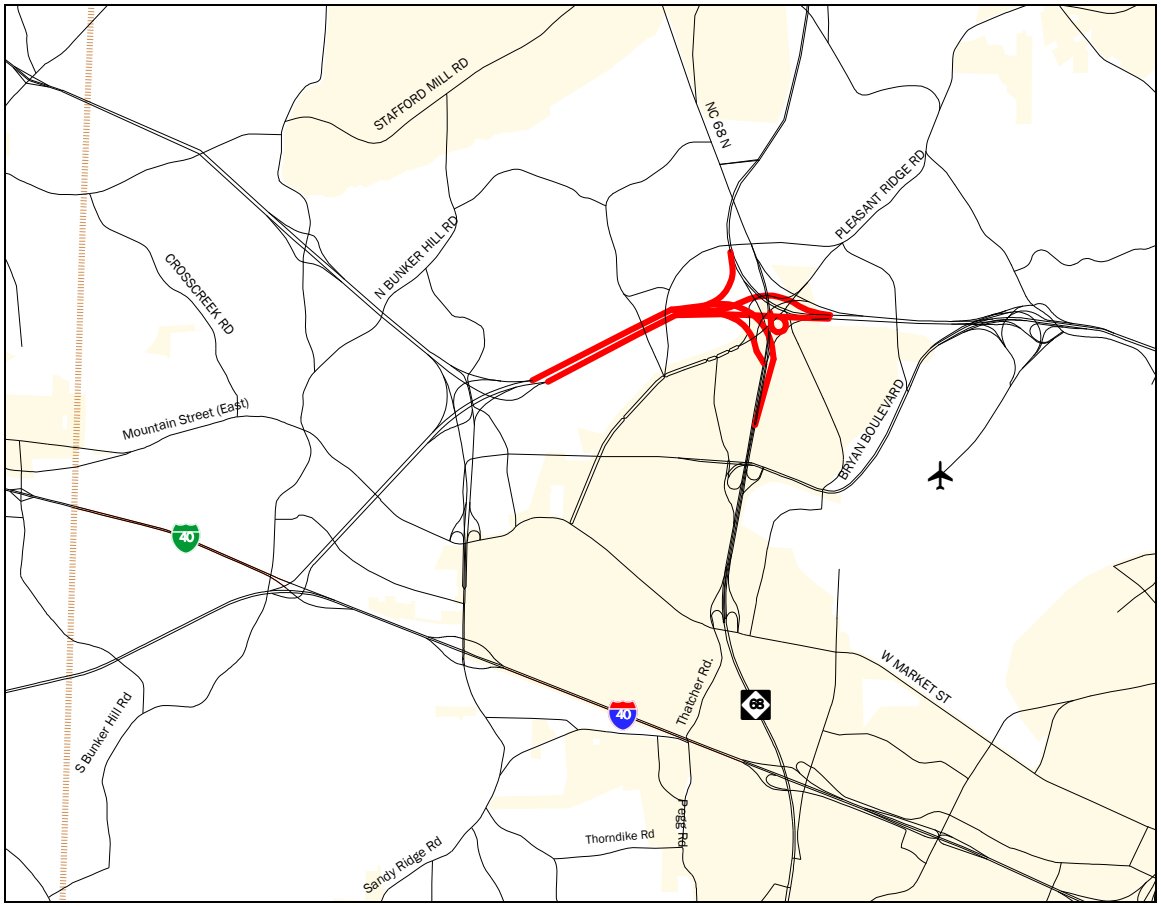


3.10 Airport Connector

This project constructs a new facility between the proposed I-73/I-74 Connector and the proposed I-73 Connector. The proposed project is a divided freeway with two lanes in each direction. This project connects to the proposed I-73/I-74 Connector at an interchange with the proposed I-40 Connector and Northern Sandy Ridge Road Extension. (As previously discussed, the cost of this interchange is associated with the I-73/I-74 Connector). Additionally, the proposed project also connects to the proposed I-73 Connector at an interchange with NC 68 and the future I-73. The location of the Airport Connector project is shown in red on Figure 13.

- Project J1 – Freeway Airport Connector – $23,125,600

Figure 13. Airport Connector Project Extents

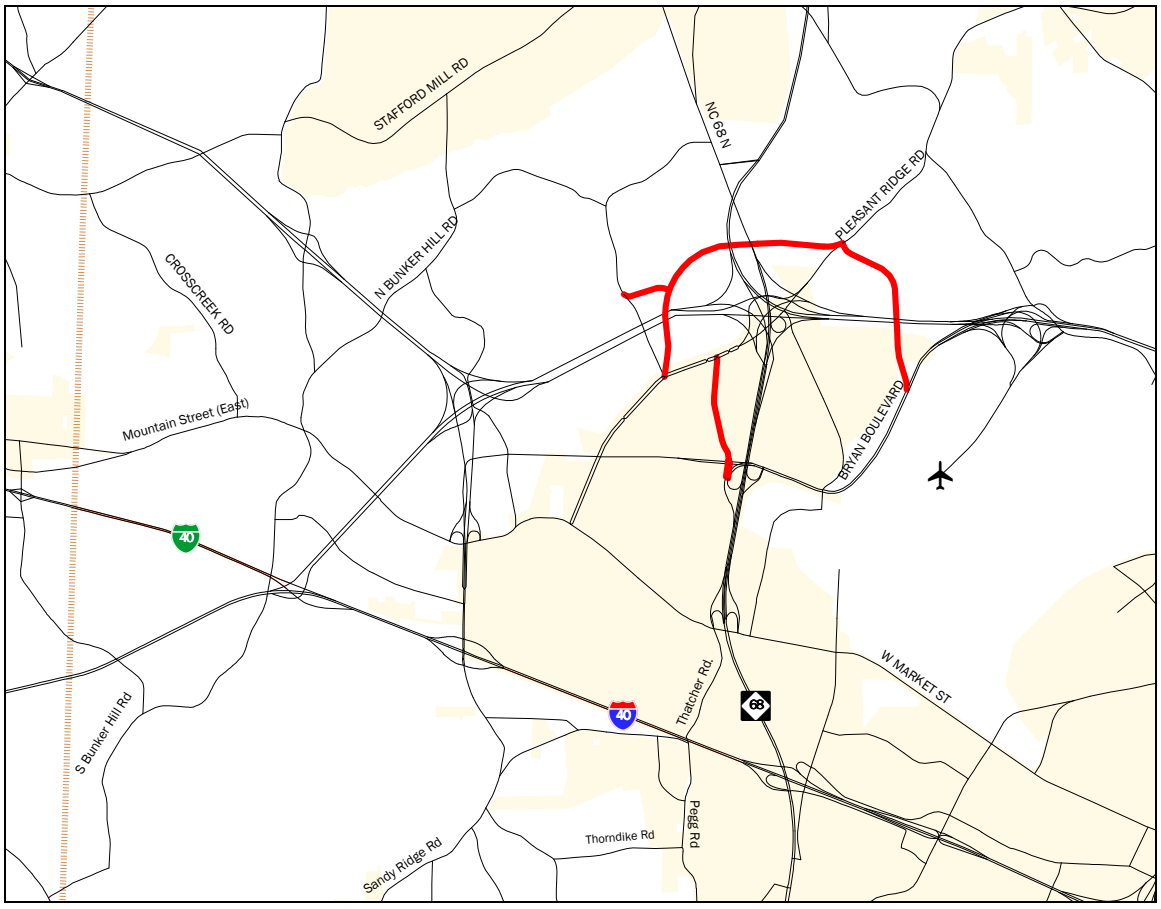


3.11 I-73 Connector Loop Roads

This project involves construction of new facilities to provide local access roads around the future I-73/proposed I-73 Connector/NC 68/proposed Airport Connector interchange. The proposed facilities are rural roads with one lane in each direction and no median. The proposed facilities will connect Joseph M. Bryan Boulevard to Pleasant Ridge Road, Pleasant Ridge Road north of the proposed I-73 Connector to Pleasant Ridge Road south of the proposed Airport Connector, and Pleasant Ridge Road south of the proposed Airport Connector to the proposed Eastern Sandy Ridge Road Extension at the Joseph M. Bryan Boulevard/NC 68 interchange. The location of the I-73 Connector Loop Roads project is shown in red on Figure 14.

- Project K – I-73 Connector Loop Roads – $37,748,635

Figure 14. I-73 Connector Loop Roads Project Extents

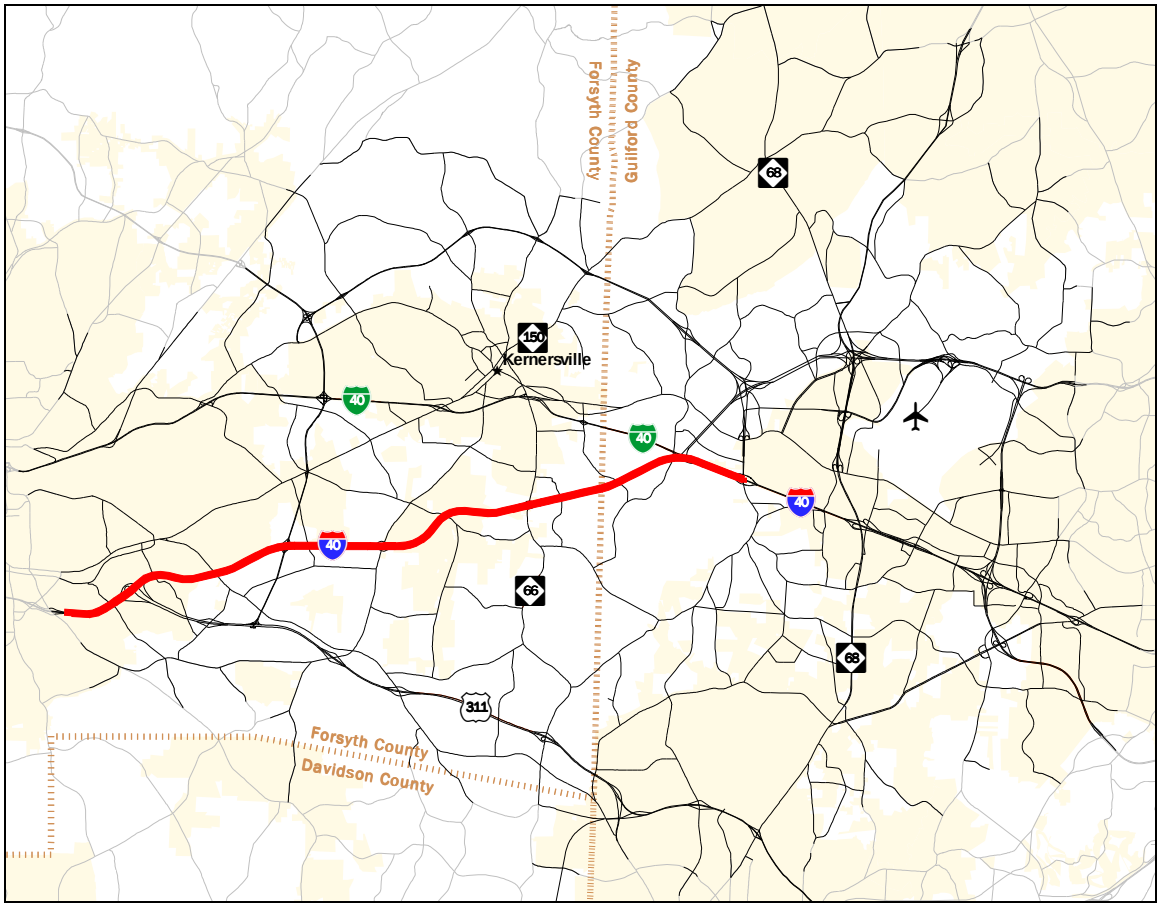


3.12 I-40 Widening

This project involves widening a portion of I-40 between NC 109 in Thomasville and NC 68 in Greensboro. Existing I-40 is a divided freeway with two lanes in each direction between NC 109 and the I-40/Business I-40 interchange and four lanes in each direction between the I-40/Business I-40 interchange and NC 68. The proposed improvements include widening to four lanes in each direction between NC 109 and the I-40/Business I-40 interchange, and widening to five lanes in each direction between the I-40/Business I-40 interchange and NC 68. The proposed project also adds loop ramps at the Old Salem Road/I-40 and Sandy Ridge Road/I-40 interchanges. The location of the I-40 widening project is shown in red on Figure 15.

- Project L1 – Existing I-40 – $0
- Project L2 – Widened I-40 – $444,100,000

Figure 15. I-40 Widening Project Extents



3.13 Evaluation Scenarios

There are 9,214 possible project scenarios, representing every possible combination of the twelve projects, ranging from solely widening Sandy Ridge Road to constructing all of the new projects listed above. The purpose of evaluating all combinations is to understand the cumulative travel benefits of individual projects, as well interactions among multiple projects. For example, both the Sandy Ridge Road widening and Extension projects may have individual benefits, but when constructed in combination, they may have even greater benefit.

4 Travel Demand Model Review

A critical component of the traffic analysis for this project is the preparation of year 2035 subarea traffic forecasts for project scenario testing. Because results from this study will be used for the Sandy Ridge Feasibility Study, it is important that the subarea traffic forecasting approach be consistent with adopted regional data and procedures. This chapter documents the approach for developing year 2035 subarea traffic forecasts using the TransCAD software package.

4.1 Use of the Piedmont Triad Regional Travel Demand Model

A key input into the process is the 2002 approved version of the Piedmont Triad Regional Travel Demand Model. This model utilizes the TransCAD software platform along with recent land use and road network information to forecast the regional demand to 2035. The base year model is calibrated for 2002 conditions and the forecast year model represents 2035 conditions. The model was developed for the entire Piedmont Triad Regional area and includes detailed zone and network systems within Forsyth, Guilford, and Alamance Counties. The model also includes portions of Davidson and Randolph Counties.

4.2 Land Use Assumptions

One of the primary inputs for the PRT TDM is land use data, which is used to estimate trip generation information. Land use information is summarized within traffic analysis zones (TAZs), which represent geographical boundaries that contain many individual parcels. The PRT TDM employs eight land use data categories for each TAZ:

- Households
- School Students
- Highway Retail Employees
- Industrial Employees
- Retail Employees
- Service Employees
- Office Employees
- School Employees

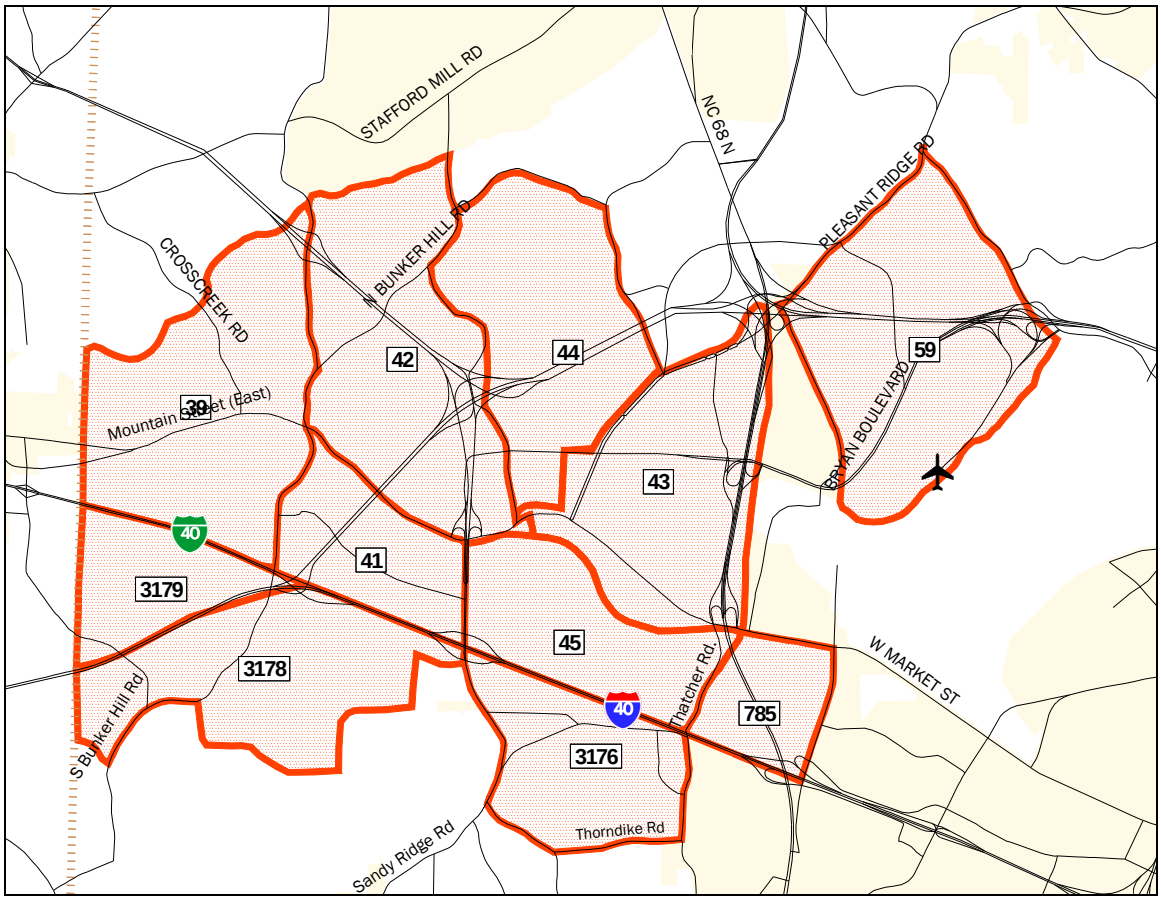
For the purposes of this study, the land use data contained in the approved 2009 and 2035 Existing + Committed (E+C) scenarios was used. However, the land use forecast within the PTIA area was thoroughly reviewed by GUAMPO staff and adjusted to account for recent development proposals that could significantly affect the future transportation network planning in the area.

GUAMPO staff recommended changes within the PTIA area, which were included in the land use assumptions for the 2035 model runs, as shown in Table 2 and Figure 16:

Table 2. 2035 Land Use Changes

TAZ	HH	HWY RET	IND	RETAIL	SERVICE	OFFICE	SCHOOL
Existing 2035 Data							
39	0	0	438	21	61	57	0
41	92	412	0	260	391	0	0
42	467	9	509	147	561	0	107
43	0	0	3,329	430	1,318	0	0
44	407	26	432	225	232	84	0
45	0	141	2,714	3,046	1,096	1,298	0
59	0	39	2,887	1,064	3,256	1,662	0
785	0	0	2,124	1,667	3,024	433	0
3176	0	0	634	2,749	1,386	463	0
3178	0	193	7	514	1,181	50	0
3179	0	0	0	0	0	0	0
Land Use Changes							
39	0	0	+380	+18	+53	+49	0
41	+500	+2,294	0	+1,448	+2,178	0	0
42	-300	+17	+966	+279	+1,065	0	+203
43	0	0	-1,134	-146	-449	0	0
44	-200	+66	+1,094	+570	+587	+213	0
45	0	-60	-1,146	-1,287	-463	-548	0
59	0	-9	-648	-239	-731	-373	0
785	0	0	-1,245	-977	-1,772	-254	0
3176	0	0	-12	-53	-26	-9	0
3178	0	-10	0	-26	-61	-3	0
3179	0	0	+100	+64	+30	+6	0
Airport Area Study 2035 Data							
39	0	0	818	39	114	106	0
41	592	2,706	0	1,708	2,569	0	0
42	167	26	1,475	426	1,626	0	310
43	0	0	2,195	284	869	0	0
44	207	92	1,526	795	819	297	0
45	0	81	1,568	1,759	633	750	0
59	0	30	2,239	825	2,525	1,289	0
785	0	0	879	690	1,252	179	0
3176	0	0	622	2,696	1,360	454	0
3178	0	183	7	488	1,120	47	0
3179	0	0	100	64	30	6	0

Figure 16. 2035 Land Use Changes TAZ Map



4.3 Roadway Network Assumptions

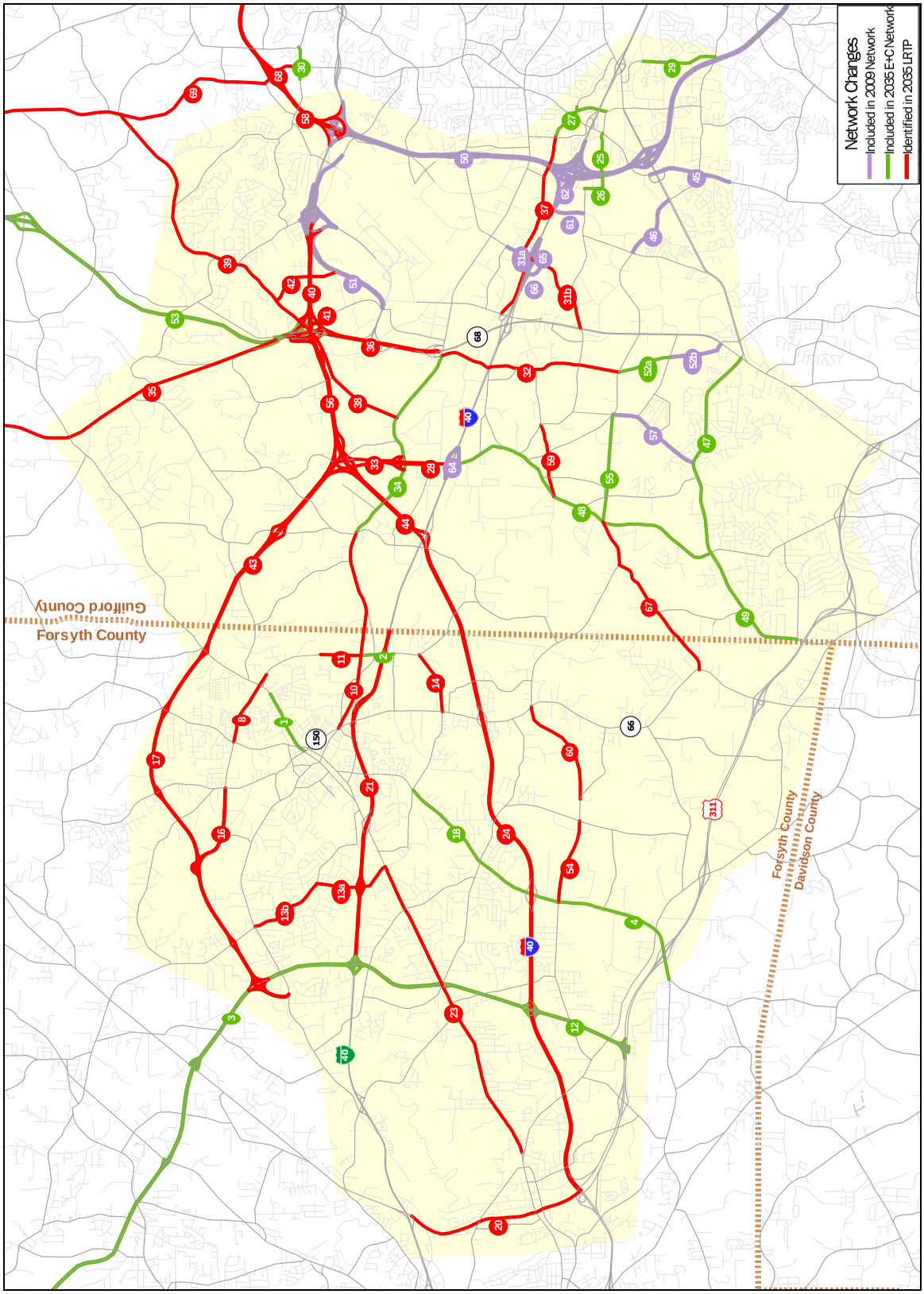
The roadway network for the 2009 and 2035 E+C conditions is based on the 2008 approved model roadway centerline file. The model roadway networks include all state routes, arterials, collectors, and important local roads within the study area. The roadway network database includes street name, distance, and generalized functional class. In addition to these attributes, speed, capacity, number of lanes, median presence, and signals per mile were coded. The roadway attributes are used by the travel demand model to estimate the vehicular capacity for each roadway segment.

The 2009 model roadway network represents existing conditions and includes only roadways operational in 2009. The 2035 E+C model roadway network includes both existing roadways and roadway projects with funding commitments that are anticipated to be operational by 2035. There are a number of proposed roadway improvements in the PTIA area that are accommodated in the forecasting process based on input from the Steering Committee. The Piedmont Triad Regional Travel Demand Model was inspected and modified to ensure that the 2035 roadway network included the improvements listed in Table 3 and shown on Figure 17. Projects identified in the area 2035 LRTPs are also listed in the table and figure, which include the twelve projects under evaluation in the PTIA area.

Table 3. Network Changes Description

ID	Project Name	Project Limits	Existing	Proposed
		Included in 2009 Network		
31a	Gallimore Dairy Road	International Drive to Albert Pick Rd	2 lane	4 lane divided
45	Guilford College Road (SR 1546)	High Point Rd (SR 4121) to south of Wendover Ave (SR 1541)	2 lane	4 - 5 lane
46	Piedmont Parkway Extension	Tarrant Road to W. Wendover Avenue		4 lane divided
50	I-840	Bryan Boulevard to I-85		6 lane freeway
51	Bryan Boulevard Extension / Relocation	Old Oak Ridge Road to Regional Road		4 lane freeway
52b	Penny Road	NC 68 to Willard Dairy Road		4 lane divided
57	Barrow Road	Clinard Farms Road to Skeet Club Road		4 lane divided
61	Boulder Road	Chimney Rock Road to Burnt Poplar Rd		2 lane undivided
62	Chimney Rock Road	Hornaday Road Extension to Burnt Poplar Rd	2 lane	remove road
64	Sandy Ridge Road Ramps to I-40	I-40 at Sandy Ridge Road	ramps	standard diamond
65	Gallimore Dairy Road Ramps to I-40	I-40 at Gallimore Dairy Road		diamond and butterfly ramps
66	Albert Pick Road	Albert Pick Road to Gallimore Dairy Road (relocation)	2 lane	2 lane undivided
		Included in 2035 E+C Network		
1	North Main Street (NC 150)	NC66 to Clay Flynt Road		3 lane
2	SR 2601 (Macy Grove Road)	New Location and Convert Grade Separation at I-40 Business to an Interchange.		Build Interchange ; 4 lane divided
3	74)	(Reidsville Road)		New 4 - 6 lane freeway
4	Union Cross Road (SR 2643)	I-40 to High Point Road	2 lane	3 lane and 4 lane divided
12	74)	(Reidsville Road) to US 52)		New 4-6 lane divided
18	Union Cross Road (SR 2643)	Widening from Wallburg Road (SR 2691) to Whicker Road (SR 2640)	2-3 lane	4 lane divided
25	Hornaday Road Extension	Hornaday Road to Chimney Rock Road		3 lane
26	Hornaday Road Bridge	Grade Separation over Greensboro Urban Loop		3 lane
27	Bridford Parkway Extension	Hornaday Road to Burnt Poplar Road		4 lane divided
29	Stanley Road	Koger Boulevard to Hilltop Road	2 lane	5 lane
30	Horsepen Creek Rd / Fleming Rd Connector	Isaacson Boulevard to Inman Road		4 lane divided
34	West Market Street	Bunker Hill Road to NC 68	2 lane	4 lane divided
47	Skeet Club Road	NC 68 to Johnson Street	2 lane	4 - 5 lane
48	Johnson Street/Sandy Ridge Road	Skeet Club Road to I-40	2 lane	4 lane divided
49	Skeet Club Road	Johnson Street to US 311	2 lane	4 - 5 lane
52a	Penny Road	Willard Dairy Road to Clinard Farms Road		4 lane divided
53	NC 68 / US 220 Connector	NC 68 to US 220		4 lane freeway
55	Piedmont Parkway Extension	Johnson Street to Barrow Road		4 lane divided
		Identified in 2035 LRTP		
8	N. Main St./Piney Grove Rd. Connector	North Main Street (NC 150) to Piney Grove Road (SR 1969)		New 4 lane divided
10	1008	NC 66 to SR 2001 (Winthrop Street) in Guilford County. Widen to Multi-Lanes.	2 lane	5 lane
11	Macey Grove Road Extension (North)	SR 1005 (East Mountain Street) to NC 150 (North Main Street).		New 4 lane divided
13a	Business I-40 (US 421) Interchange at Big Mill Farm Road	Hopkins Road to S. Main Street		New Interchange 4 lane divided
13b	Business I-40 (US 421) Interchange at Big Mill Farm Road	Hopkins Road to NC 66		4 lane divided
14	Macey Grove Road Extension (South)	NC 66 to Industrial Park Drive		New 4 lane divided
16	Linville Springs Road (SR 2030) Extension	Piney Grove Road (SR 1969) to I-73/74 Connector (Regional Aiport Connector)		New 4 lane divided
17	I-73 - I-74 Connector	Northern Beltway/West Mountain Street to Guilford County		New 4 lane freeway
20	US 311 Connector	I-40 to Business I-40		New 4 lane divided
21	Business I-40 (US 421)	Northern Beltway to Guilford County	4 lane freeway	6 lane freeway
23	Kernersville Road (SR 4315)	High Point Road (SR 1003) to Whicker Road	2 lane	3 lane
24	I-40	US 311 to Business 40 Split	4 lane freeway	6 lane freeway
28	Sandy Ridge Road	I-40 to West Market Street	2 lane	4 lane divided
31b	Gallimore Dairy Road	NC 68 to Albert Pick Rd	2 lane	4 lane divided
32	Pegg / Thatcher Connector	W Market Street to Clinard Farms Rd		4 lane divided
33	Sandy Ridge Road Extension	West Market Street to I-40 / NC 68 / I-73 Connector		4 lane divided
35	NC 68	Peeples Road to Rockingham County	2 lane	4 lane divided
36	NC 68	Market Street to Pleasant Ridge Road	4 lane	6 lane divided
37	Burnt Poplar Road	Swing Road to Regional Road	2 lane	3 lane
38	Pleasant Ridge Road	West Market Street to City Limits	2 lane	4 lane divided
39	Pleasant Ridge Road	City Limits to Old Oak Ridge Rd	2 lane	4 lane divided
40	I-73 Connector	NC 68 to Bryan Boulevard		4 lane freeway
41	Pleasant Ridge Road Relocation at I-73 Connector	Montmartre Road to Cude Road		3 lane
42	Bryan Boulevard Loop at I-73 Connector	Montmartre Road to Pleasant Ridge Road		4 lane divided
43	I-73 - I-74 Connector	Forsyth County to NC 68		4 lane divided
44	I-40 Connector	I-40 to I-73 / I-74 Connector		4-6 lane freeway
54	Glenn High Road Extension	Union Cross Road to Teague Lane		4 lane divided
56	Airport Connector	I-73 - I-74 Connector to NC 68		4 lane freeway
58	I-840	Bryan Boulevard to US 220 / US 29		6 lane freeway
59	Thorndike Road	Gallimore Dairy Road to Sandy Ridge Road		2 lane undivided
60	Bunker Hill Sandy Ridge Road	NC 66 to Teague Lane		4 lane divided
67	Winston-Salem North/South Connector	NC 66 to Johnson Street on Squire Davis Road / Sandy Ridge Road	2 lane	4 lane undivided
68	Flemington-Lewiston Connector	Fleming Road to Lewiston Road Connection		4 lane divided
69	Lewiston Road / Pleasant Ridge Road	Urban Loop to NC 150 Relocation	2 lane	4 lane divided

Figure 17. Network Changes Map



4.4 Performance Testing

Model validation is the term used to describe how closely the model's output matches existing travel data in the base year. The 2008 approved model met NCDOT travel demand model validation guidelines, and base year performance was deemed acceptable. However, the NCDOT validation guidelines measure only the model's ability to replicate a static set of conditions (traffic counts). While this provides useful information, its value is limited because the purpose of this study is to forecast how changes in the roadway network would change traffic conditions.

A more valid test of a model's accuracy would focus on the model's ability to predict realistic differences in outputs as inputs are changed; in other words, dynamic validation rather than static validation. In order to review the model's dynamic validation within the PTIA area, the following two tests were performed.

The first test was to see how the model responds to the removal of a link in the road network. For this test, a critical north-south connection was removed, NC 68 between the I-40 on- and off-ramps. Table 4 summarizes the results of this test. The majority of traffic is rerouted to the four parallel connections. As would be expected, there is a small drop in total traffic, since increased congestion and less direct access across I-40 shifts some of the trips to other crossing points along I-40 outside of the testing area.

Table 4. Removal of a Link in the Network

I-40 Overcrossing	With NC 68	Without NC 68	Ratio
Sandy Ridge Road	15,187	20,189	1.33
NC 68 NB	14,565	0	n/a
NC 68 SB	16,497	0	n/a
Gallimore Dairy Road	11,065	22,277	2.01
South Regional Road	7,851	8,808	1.12
Chimney Rock Road	12,890	13,730	1.07
Total	**78,055**	**65,004**	**0.83**

The second test assessed the model response to adding a link to the road network. For this test, the proposed Pegg Road/Thatcher Road extension under I-40 was added. Table 5 summarizes the results of this test. Again, as would be expected, traffic decreases on the five parallel roadways and is rerouted to take advantage of the new capacity on Thatcher Road. In addition, there is a small increase in the total amount of traffic, due to the induced demand of additional roadway facilities.

Table 5. Addition of a Link to the Network

I-40 Overcrossing	Without Thatcher Road Connection	With Thatcher Road Connection	Ratio
Sandy Ridge Road	15,187	12,377	0.81
Thatcher Road	0	6,812	n/a
NC 68 NB	14,565	14,296	0.98
NC 68 SB	16,497	14,890	0.90
Gallimore Dairy Road	11,065	10,195	0.92
South Regional Road	7,851	7,235	0.92
Chimney Rock Road	12,890	12,806	0.99
Total	**78,055**	**78,611**	**1.01**

The results of the dynamic validation tests confirm that the model produces reasonable results for the model application this study requires.

5 Travel Demand Model Forecasting Methodology

This chapter describes the methodology used to develop traffic forecasts for the various projects in the PTIA area. Each step is described in more detail below.

5.1 2035 E+C Model Base Run

A full execution of the Piedmont Triad Regional Travel Demand Model requires approximately twelve hours to complete, while the traffic assignment portion alone requires approximately two hours. Given the number of scenarios that are under evaluation, it would take approximately twelve years to fully execute the model for each scenario. For these reasons, the use of a subarea model representing a smaller geographic portion of the Piedmont Triad Regional Travel Demand Model was selected for this study.

In support of this approach, the 2035 E+C Piedmont Triad Regional Travel Demand Model was run with the land use and roadway network changes described in the previous chapter to develop the baseline origin-destination information for the subarea model. The PM peak hour subarea origin-destination trip tables from the 2035 E+C Piedmont Triad Regional Travel Demand Model were extracted for use in the subarea model.

5.2 Subarea Model Development

To decrease the time required to perform individual scenario runs, the full Piedmont Triad Regional Travel Demand Model was used for the trip generation, trip distribution, and mode choice steps, while the subarea model was used for traffic assignment steps within the project study area. Additionally, the traffic assignment step within the subarea was further streamlined by collapsing the number of vehicle classification bins from 14 (single occupant vehicle, single occupant vehicle toll, high-occupancy vehicle 2, high-occupancy vehicle 2 toll…) to two (personal vehicle and commercial/heavy vehicles). The resulting subarea model required approximately 30 seconds to complete the traffic assignment step within the study area.

5.3 Subarea Model Scenario Runs

A subarea model batch routine was created to execute the traffic assignment step for all of the project scenarios. This took approximately 77 hours to complete using the origin-destination information from the full 2035 E+C Piedmont Triad Regional Travel Demand Model. Twenty-five sets of the resulting traffic forecasts data were reviewed in detail to ensure that the project scenarios were correctly coded and that the resulting traffic forecasts were reasonable.

6 Subarea Model Results

6.1 Traffic Statistics

The travel demand forecasting for this project was accomplished using a combination of the most recent Piedmont Triad Regional Travel Demand Model (with land use and roadway network modifications as previously described) and a subarea travel demand model representing a portion of the model within the PTIA area.

It is important to recognize that regional models such as the Piedmont Triad Regional Travel Demand Model typically represent only major components of the roadway network and are calibrated/validated to the level of screenlines and major corridor volumes. These models are best-suited to forecast regional-level traffic patterns, and usually lack sufficient detail to provide reasonable forecasts at the intersection turning movement level.

As a result, specific traffic volumes were not used as performance measures; rather the following aggregate statistics were calculated over the entire subarea for each scenario:

- Vehicle miles traveled (VMT)
- Vehicle hours traveled (VHT)
- Vehicle hours of delay (VHD)

While each measure is a standard aggregate reporting statistic for travel demand model work and is helpful for comparing scenarios against each other, VHD was selected as the most meaningful statistic for this study because it directly measures traffic congestion. Specifically, it indicates the additional time spent on the network due to other traffic.

VHD is inversely related to user benefit; a reduction in VHD results in reduced travel time and decreased idle time, which saves money and lessens pollutants. Alternatively, VMT and VHT are not directly related to user benefit; while an increase in VMT or VHT does lead to increased travel and mobility, the additional travel also results in increased air pollution and promotes non-dense development patterns. Furthermore, changes in VMT and VHT are more beneficial to longer trips, which are typically regional in nature (especially along I-40 through the study area).

6.2 Evaluation Criteria

As noted in the first chapter, the purpose of this study is to evaluate the various proposed roadway projects and alternatives in the PTIA area. The evaluation of these projects will improve GUAMPO's decision-making by providing objective and comparative measures of project performance. This performance includes traffic statistics along with cost information, provided earlier in the report. The following section provides benefit/cost analysis information that provides insight into the return on investment for the different projects. Ultimately, this information is most useful for designing a project implementation plan intended to meet specific GUAMPO objectives.

6.3 Project Scenario Analysis

The model data and cost information were combined to create the following variables:

- Projects – Number of individual projects included in each scenario, ranging from one to twelve.
- Cost (Million) – Total cost of the projects included in each scenario, in millions of dollars.
- VHD Reduction – Difference in VHD between each scenario and the base scenario (2035 E+C network, no scenario projects).
- VHD Reduction/Project – Total VHD reduction per number of projects included in each scenario.
- VHD Reduction/Cost (Million) – Total VHD reduction per scenario cost.

Due to the large number of scenarios under evaluation, the initial screening of scenario performance involved the creation of Figures 18 through 22, which compare the scenario variables by highlighting different relationships.

Figure 18 compares the scenario cost with its corresponding VHD reduction. As shown on the figure, almost all scenarios result in a VHD reduction from the base case (2035 E+C: 15,047 VHD), with a maximum reduction of approximately 6,100 VHD.

Figure 18. Cost (Million) vs. VHD Reduction

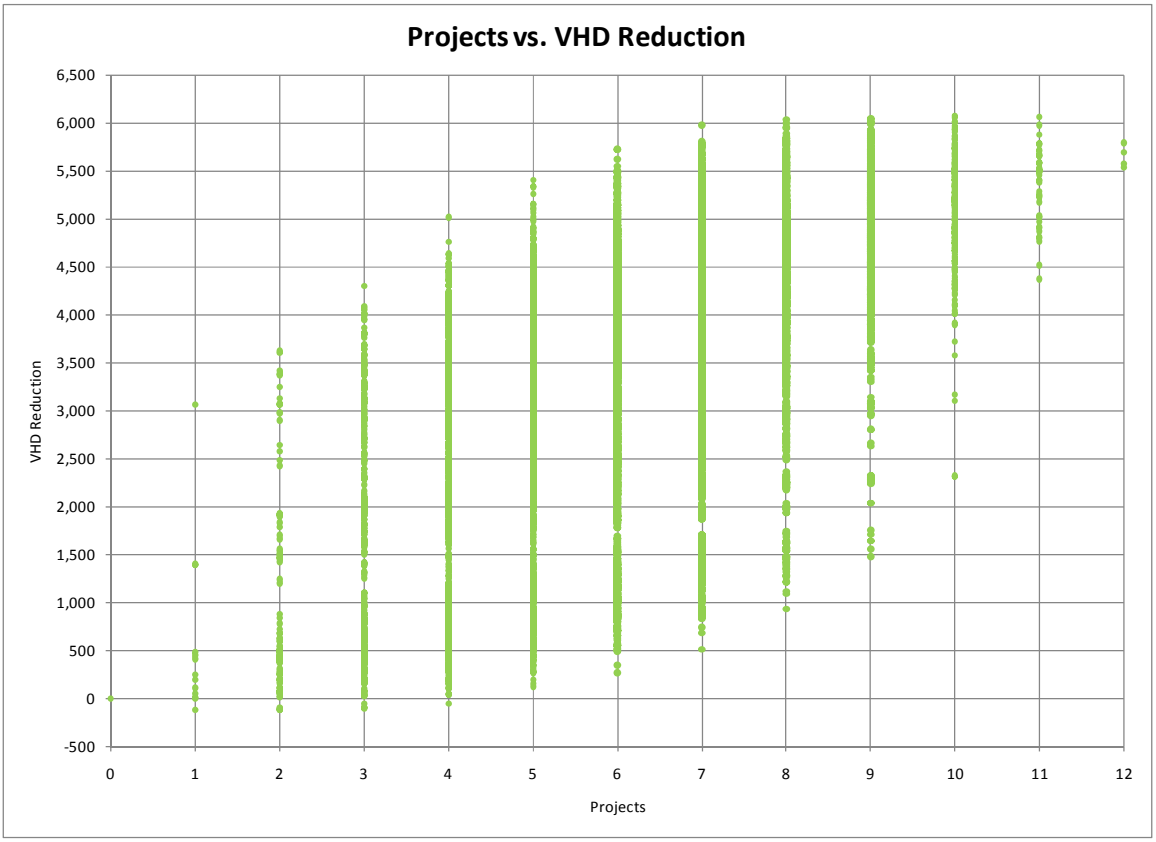
actually increase VHD (These scenarios include projects that may eliminate a bottleneck in one area, only to move it to another, more constrained location). The most interesting finding from this figure is the tradeoff between cost and VHD reduction.

While the general trend indicates increasing cost yields a higher VHD, there is a wide range of performance at each cost increment. For example, spending approximately $600 million can generate a VHD reduction ranging from approximately 2,200 to 5,000, depending on which specific projects are built. This result indicates that the combination of projects (especially complimentary projects such as the I-73 Connector and the Airport Connector) has more influence on VHD reduction than does the total cost of the scenario.

Figure 18 also begins to reveal the issue of diminishing returns -- a topic covered in more detail in the discussion of Figure 21. For example, doubling the infrastructure investment by adding a second $600 million in projects yields only 20% of the delay reduction obtained from the first $600 million investment (assuming that $600 million was optimally spent).

Figure 19 organizes results by comparing the number of projects in a scenario to the VHD reduction. The general trend indicates that the more projects a scenario has, the larger the VHD reduction. That being said, the specific combination of projects can result in drastically different VHD reduction levels. For example, scenarios with seven projects can result in VHD reductions between approximately 500 and 6,000. These results further confirm that the specific combination of projects is the most important predictor of VHD reduction, even more important than the number of projects.

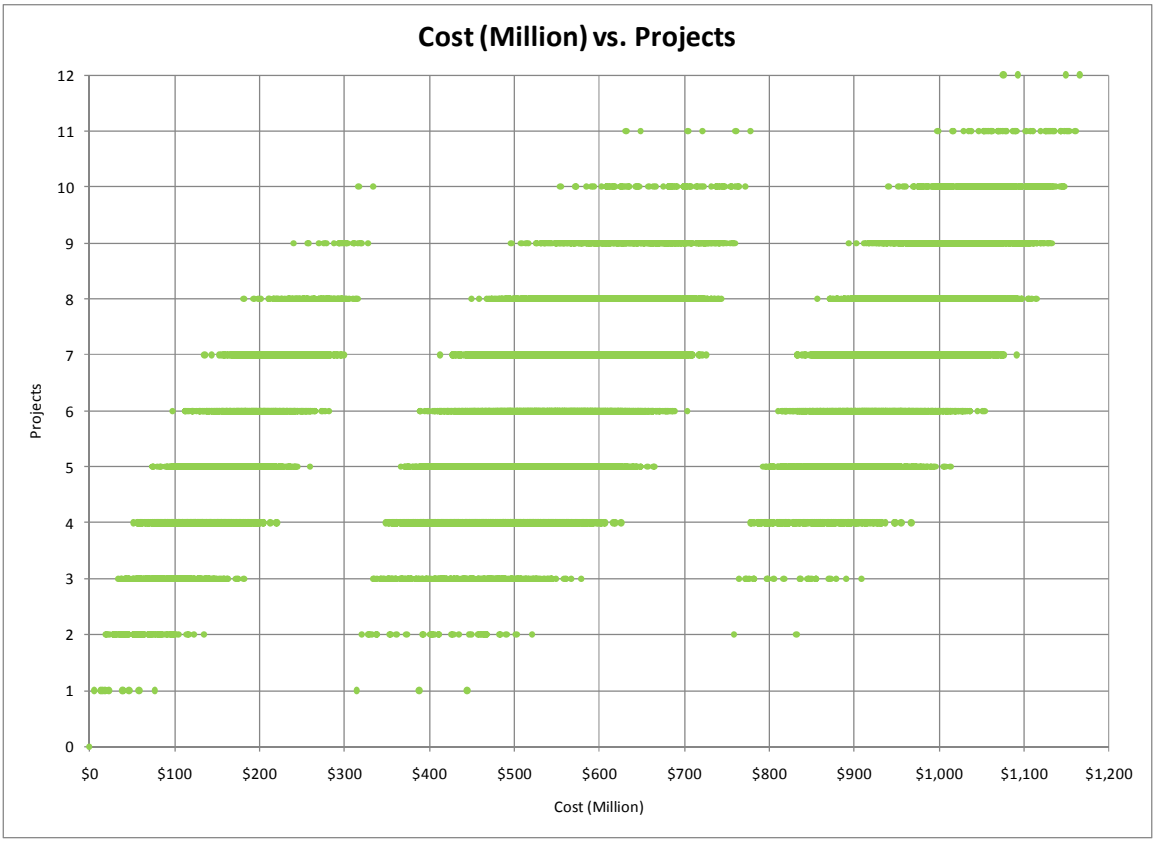
Figure 19. Projects vs. VHD Reduction



It should also be noted that the scenario yielding the highest VHD reduction (approximately 6,100) includes only ten projects. Adding an eleventh or twelfth project results in a lower VHD reduction, indicating that, while they may provide additional roadway capacity or routing options, some of these projects are redundant, especially when constructed with a host of other projects.

Figure 20 compares the cost of each scenario to the number of projects constructed. There is no clear relationship between the cost of a scenario and the number of projects. It may be expected that the number of projects in a scenario should increase with the total cost. This is not the case in the PTIA area due to huge cost differences between individual projects, specifically freeway projects versus local roadway projects. For example, spending approximately $440 million allows for a scenario that constructs only the I-40 widening project, while spending approximately $250 million allows for a scenario that constructs nine separate, smaller projects.

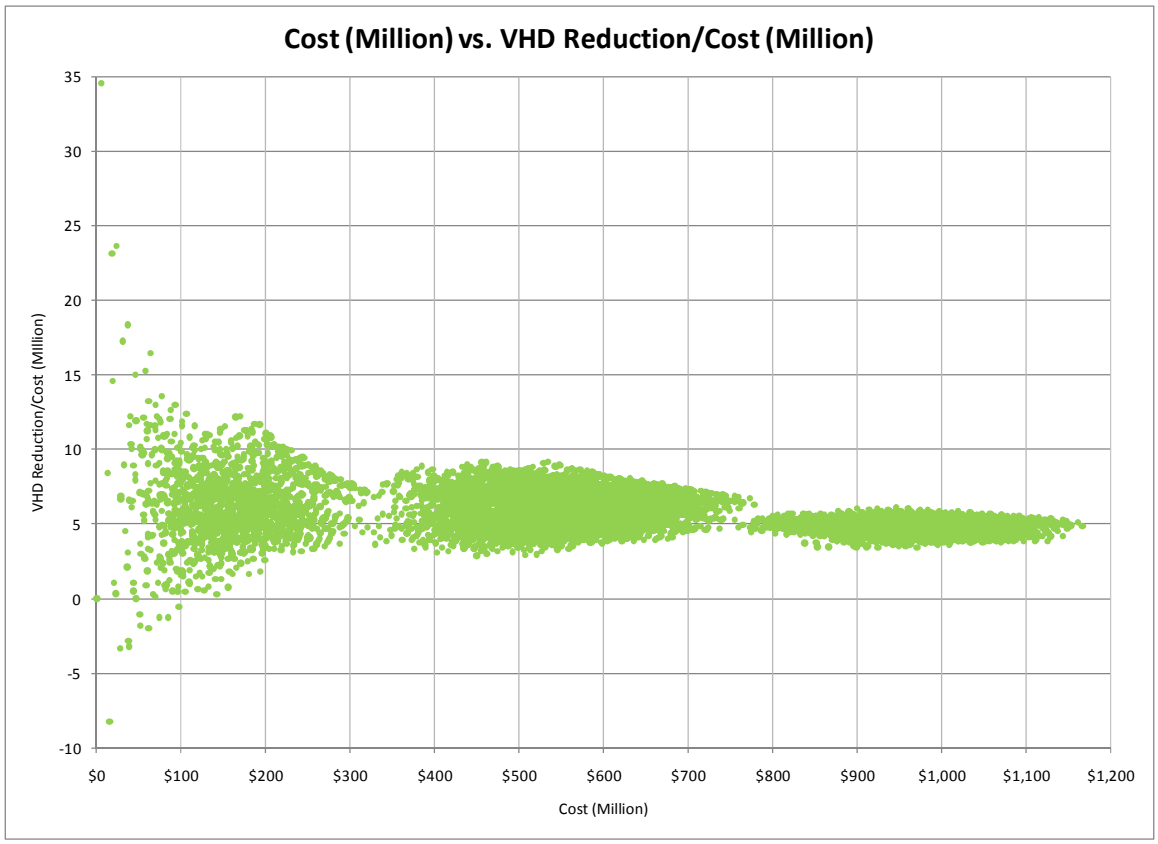
Figure 20. Cost (Million) vs. Projects



This provides additional proof that the specific combination of projects is important to scenario performance, particularly the resulting cost. A similar amount can be spent on different scenarios that construct one large project or multiple smaller projects. While the large project may yield the greatest reduction in VHD, the multiple smaller projects may still result in a substantial reduction in VHD while also addressing a host of secondary needs (local access, increased goods movement, etc).

Figure 21 compares scenario cost to VHD reduction/cost, which is essentially a measure of per dollar effectiveness (in terms of VHD reduction), for each additional dollar spent on a scenario. The general trend shows that the additional effectiveness of any dollar spent on a scenario converges around 5.0, as the total scenario cost increases. The real variation in VHD reduction/cost occurs between $0 and $300 million, which indicates some of the cheaper scenarios provide a greater VHD reduction/cost than more expensive scenarios. These scenarios primarily contain roadway widening projects, which are much less expensive than new freeway construction.

Figure 21. Cost (Million) vs. VHD Reduction/Cost (Million)

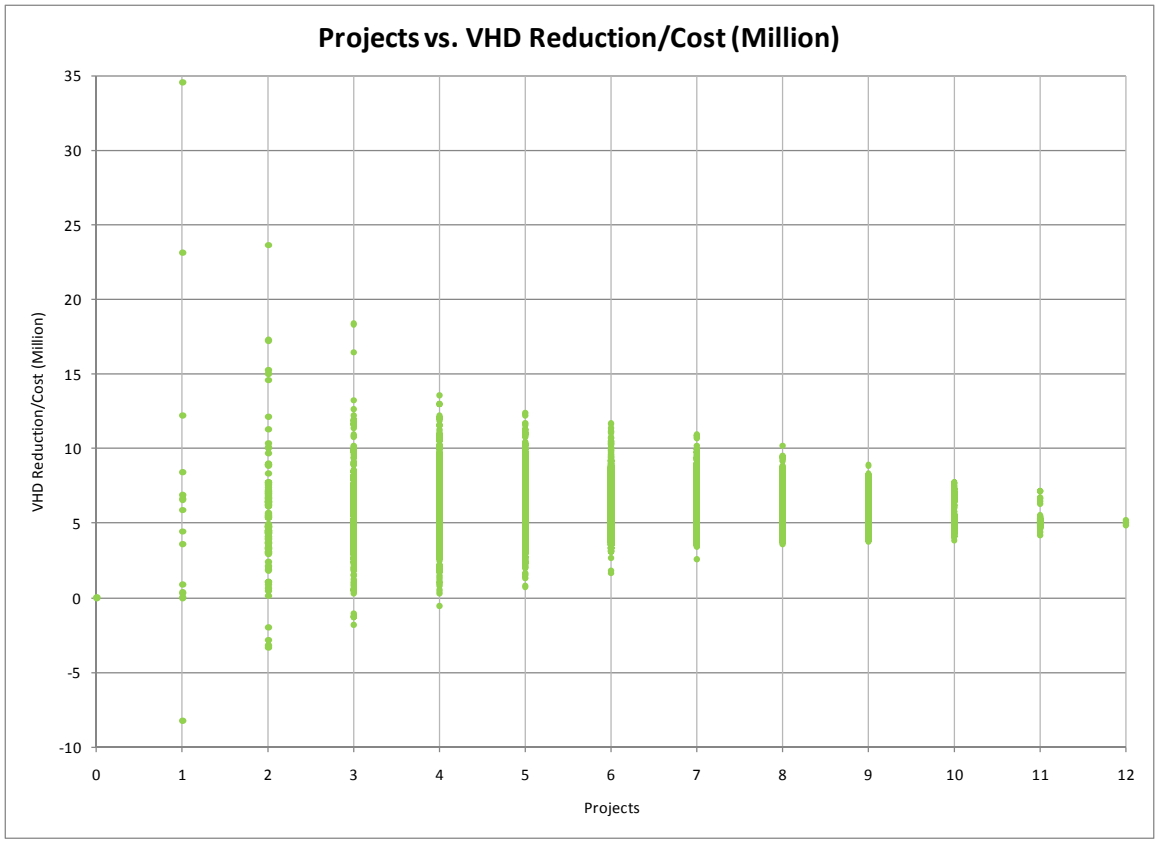


The general pattern in the figure shows that there are diminishing returns for each additional dollar spent on a given project scenario. Alternatively, there is greater VHD reduction/cost associated with the cheaper projects. This is important to acknowledge, due to the inherent risk associated with future activities, such as constructing roadway projects. In light of this, the future must be discounted because there is risk that some or all of the projects in a given scenario might not be built. History shows that money or other factors may limit the ultimate completion of all the projects.

Figure 22 compares the number of projects constructed to the corresponding VHD reduction/cost. The trend is similar to that of the previous figure, though this reveals that the top performing scenarios tend to have four or fewer projects. Additionally, the rate of return appears to flatten between seven and ten projects, and then decline further with eleven or twelve projects. Similar to the previous comments, the combination of projects

matters to the performance of a scenario. In this case, scenarios that contain more than seven projects do not provide additional VHD reduction in proportion to their additional cost.

Figure 22. Projects vs. VHD Reduction/Cost (Million)



6.4 Implementation Plan Strategies

As noted above, scenario performance is directly related to specific project combinations. While there is no prescribed method for determining the best sequence for building the projects under evaluation, there are three distinct implementation plan strategies for the PTIA area:

- Minimize cost
- Maximize VHD reduction
- Maximize VHD reduction/cost

Each strategy is viable and provides a valid basis for decision-making, though the timing and magnitude of VHD reduction and costs differ.

6.5 Minimize Cost Strategy

As shown in Table 6, this implementation plan focuses on building projects in order of increasing cost. This strategy calls for the construction of local road projects before any new freeway projects are built. This strategy is favorable from a financial standpoint, because it allows for the construction of six projects while spending less than $100 million. However, this strategy does not produce a 1,000 VHD reduction (roughly 18% of the maximum) until the seventh project.

Table 6. Minimize Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pleasant Ridge Road Widening	275	$ 18.8	14.6
3	Pleasant Ridge Road Relocation	153	$ 33.7	4.5
4	Pegg/Thatcher Street Connection	518	$ 51.6	10.0
5	Sandy Ridge Road Extension (North)	569	$ 74.3	7.7
6	Airport Connector	758	$ 97.4	7.8
7	Bryan Boulevard Loop	1,015	$ 135.2	7.5
8	I-40 Connector	1,472	$ 181.6	8.1
9	NC 68 Widening	1,559	$ 239.7	6.5
10	I-73 Connector	2,319	$ 316.5	7.3
11	I-73/I-74 Connector (Arterial)	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

6.6 Maximize VHD Reduction Strategy

As shown in Table 7, this implementation plan focuses on building projects in order of increasing VHD reduction. This strategy calls for the construction of new freeway projects before constructing any local road projects. This strategy is favorable from a traffic standpoint, because it produces a 3,059 VHD reduction (roughly 51% of the maximum) with the first project. However, this strategy frontloads the costs and surpasses $1,000 million with the construction of the seventh project. It should be noted that the "maximize VHD reduction" strategy project sequence is almost a mirror image of the "minimize cost" strategy.

Table 7. Maximize VHD Reduction Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	I-40 Widening	3,059	$ 444.1	6.9
2	I-73/I-74 Connector (Freeway)	3,602	$ 832.1	4.3
3	Airport Connector	4,296	$ 855.2	5.0
4	I-73 Connector	5,016	$ 932.1	5.4
5	I-40 Connector	5,406	$ 978.4	5.5
6	Pegg/Thatcher Street Connection	5,725	$ 996.3	5.7
7	Sandy Ridge Road Extension (North)	5,977	$ 1,019.0	5.9
8	Bryan Boulevard Loop	6,031	$ 1,056.8	5.7
9	NC 68 Widening	6,050	$ 1,114.9	5.4
10	Pleasant Ridge Road Relocation	6,078	$ 1,129.8	5.4
11	Pleasant Ridge Road Widening	6,060	$ 1,143.0	5.3
12	Sandy Ridge Road Widening	5,790	$ 1,148.6	5.0

6.7 Maximize VHD Reduction/Cost Strategy

As shown in Table 8, this implementation plan focuses on building projects in order of greatest incremental VHD reduction/cost, or the most effective projects per dollar spent. This strategy calls for the construction of local roadways before new freeway projects. This strategy is favorable from a VHD reduction/cost standpoint, because it produces a 1,250 VHD reduction (roughly 22% of the maximum) with the construction of the fifth project, for a cost of only $151.2 million. This strategy backloads the costs and requires an increment of $444.1 million between the tenth and eleventh projects. It should be noted that the "maximize VHD reduction/cost" strategy project sequence is very similar to the "minimize cost" strategy.

Table 8. Maximize VHD Reduction/Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pegg/Thatcher Street Connection	553	$ 23.4	23.6
3	Pleasant Ridge Road Widening	673	$ 36.7	18.3
4	Bryan Boulevard Loop	899	$ 74.4	12.1
5	I-73 Connector	1,250	$ 151.2	8.3
6	Pleasant Ridge Road Relocation	1,328	$ 166.1	8.0
7	Airport Connector	1,328	$ 189.2	7.0
8	I-40 Connector	2,209	$ 235.6	9.4
9	Sandy Ridge Road Extension (North)	2,299	$ 258.4	8.9
10	I-73/I-74 Connector (Arterial)	4,440	$ 573.2	7.7
11	NC 68 Widening	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

6.8 Comparison of Strategies

Figures 23 through 27 provide visual representations of the performance of the three implementation plan strategies. All three strategies perform well, especially when compared to the entire set of project combinations evaluated. While no single strategy clearly stands out as preferred, the "maximize VHD reduction/cost" strategy blends both the "minimize cost" and "maximize VHD reduction" strategies together.

Ultimately, this balance of VHD reduction and cost performance is a very reasonable strategy, and if pursued would be defendable from a cost standpoint, while also resulting in traffic improvements in the PTIA area. Additionally, the "maximize VHD reduction/cost" strategy is best for minimizing future risk. While all three strategies have similar VHD reduction at the end of the implementation plan (if all twelve projects are constructed and is considered a complete system), the "maximize VHD reduction/cost" strategy is a conservative approach that incrementally builds the best returning project out of all remaining available projects.

Since funding or other factors may halt ultimate completion of any implementation plan, the "maximize VHD reduction/cost" strategy provides interim systems that work – projects constructed in the early stages of the implementation plan are not dependent on the construction of other, future projects to realize the full value of earlier constructed projects. Therefore, a reasonable strategy is one that constructs a system that works well during all interim stages, since the ultimate completion of the implementation plan is an unknown variable that could be delayed, altered, or never fully realized.

Figure 23. Cost (Million) vs. VHD Reduction

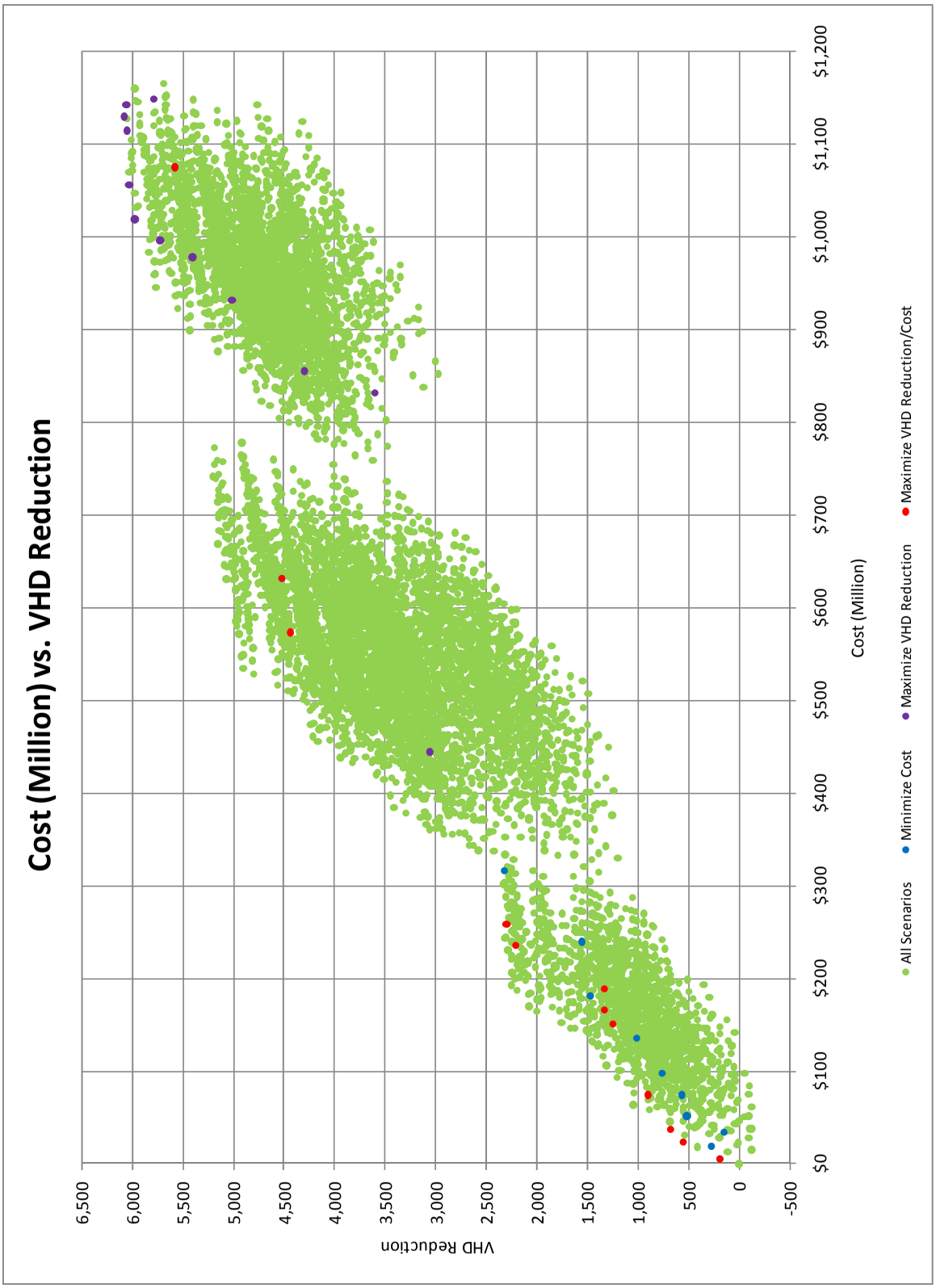


Figure 24. Projects vs. VHD Reduction

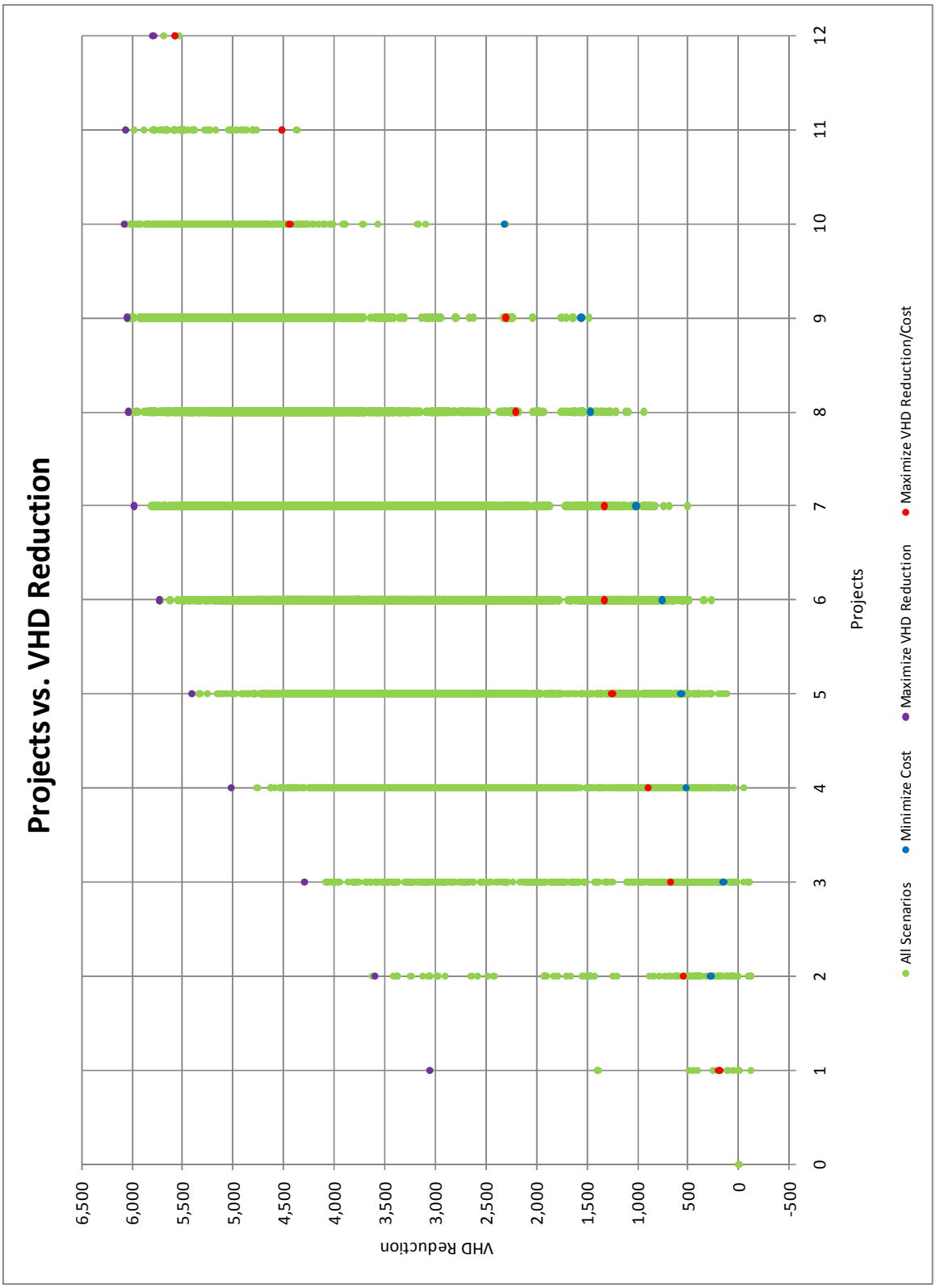


Figure 25. Cost (Million) vs. Projects

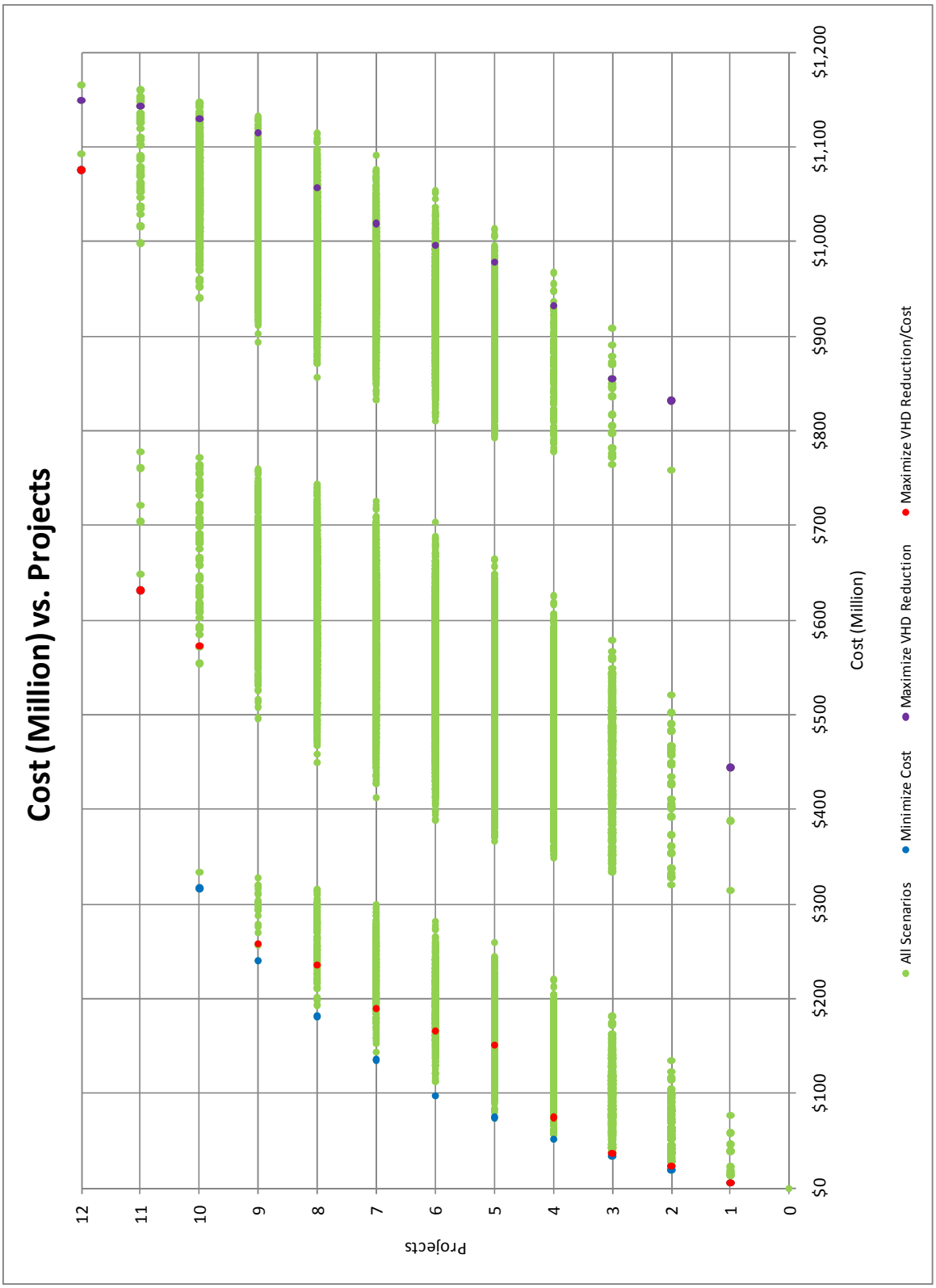


Figure 26. Cost (Million) vs. VHD Reduction/Cost (Million)

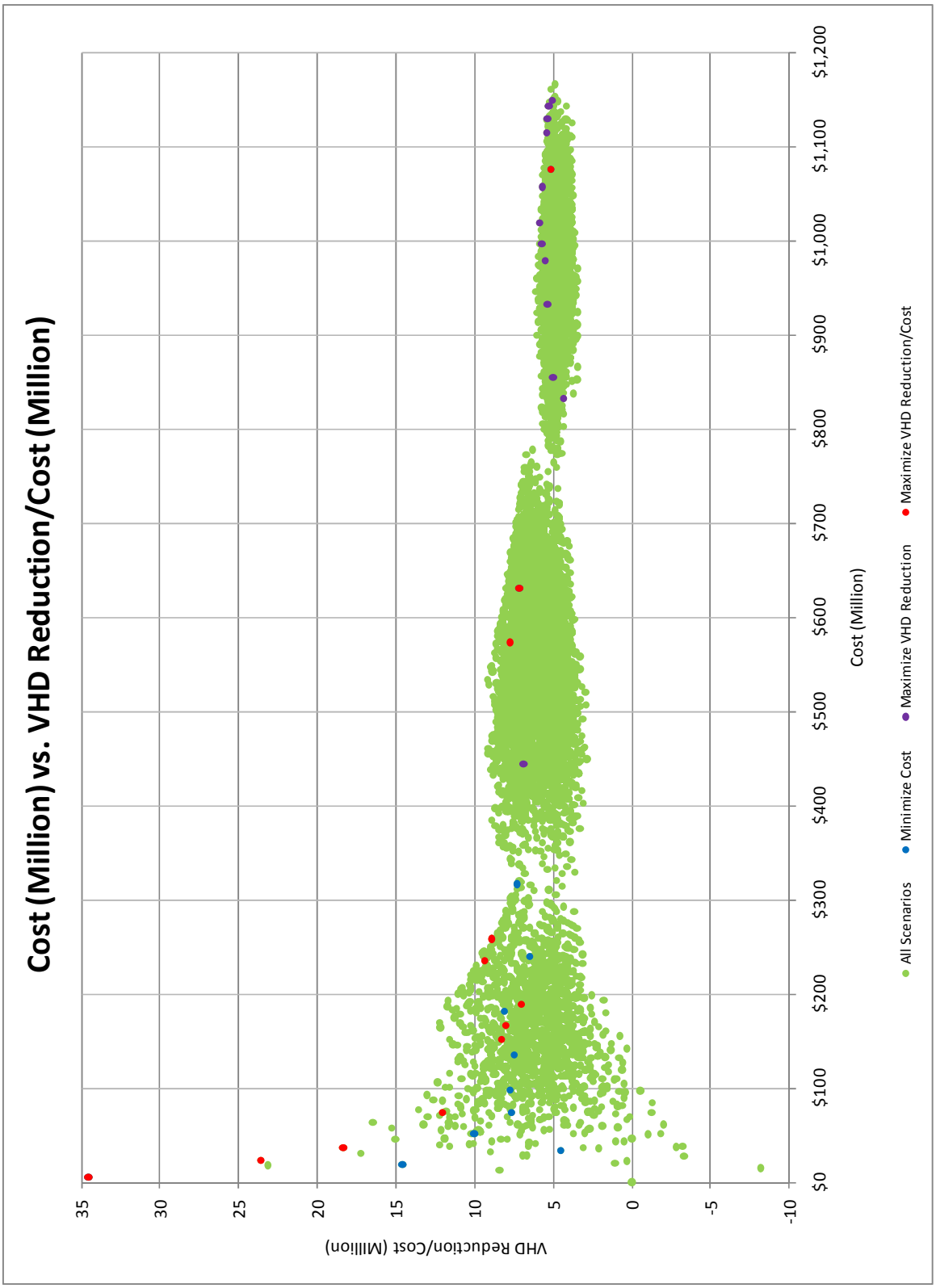
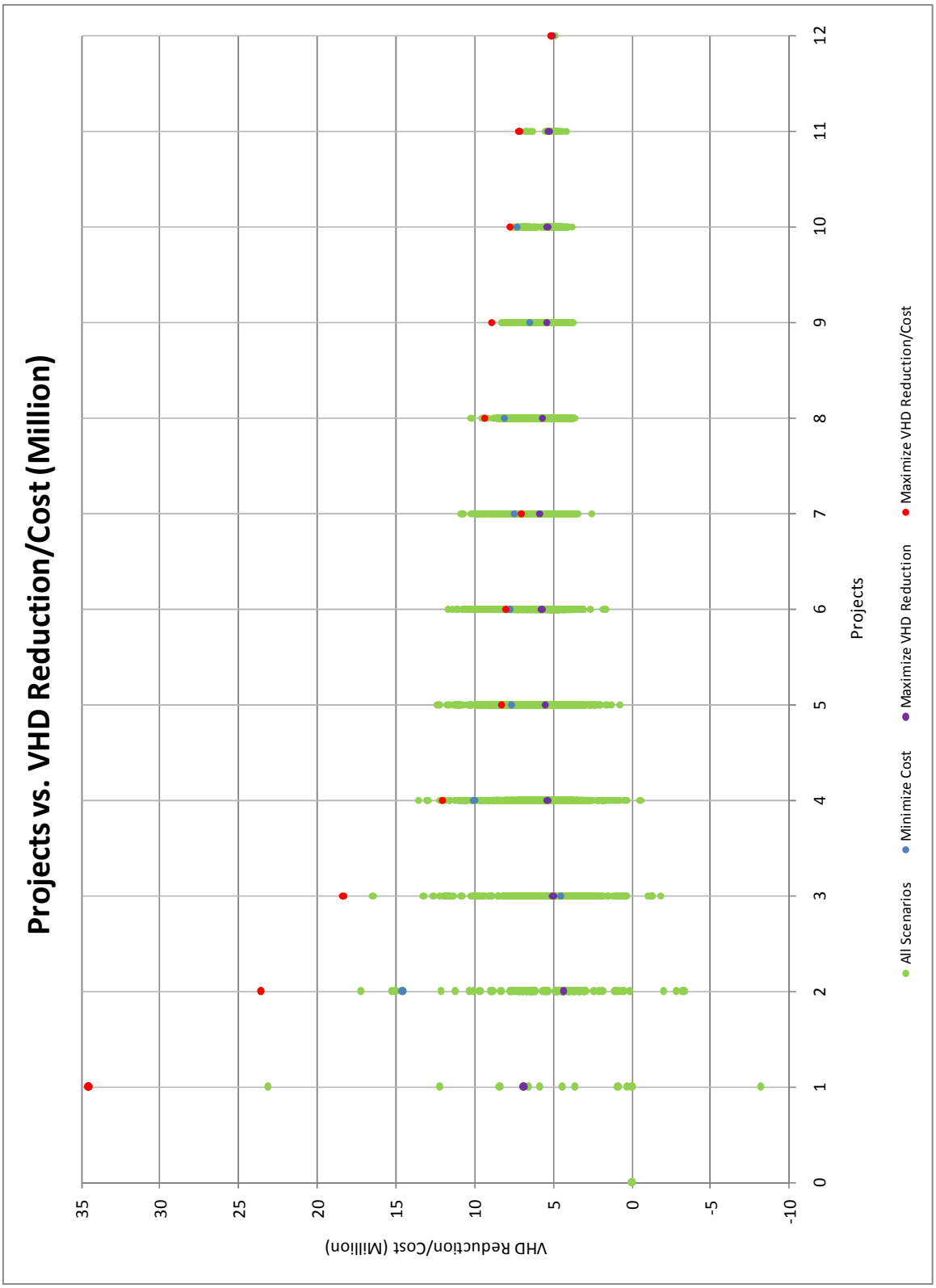


Figure 27. Projects vs. VHD Reduction/Cost (Million)



6.9 Notable Results

During the evaluation of the project scenarios and the implementation plan strategies, the following notable results became clear:

Sandy Ridge Road Widening

- Enhances Market Street widening project.
- Increases capacity parallel to I-40 by improving connectivity and access to alternate routes.
- Provides alternative access to the airport from the west and south.

Pegg/Thatcher Street Connection

- Driven primarily by land use development.
- Does not provide very equitable north-south capacity enhancements.

Sandy Ridge Road Extension

- East extension is not viable once I-73 Connector is built, due to loss of access to PTIA via Bryan Boulevard.
- North extension is viable only after the Airport Connector is built.
- A development driven collector extension could be beneficial, though no specific alternative was evaluated during the study.

NC 68 Widening

- Enhances Market Street widening project.
- Increases capacity parallel to I-73.
- Provides alternative access to the airport from the north, west, and south.

Pleasant Ridge Road Widening

- Enhances Market Street widening project.

- Reduces the need for a Sandy Ridge Road extension by providing a similar function when combined with widenings of Sandy Ridge Road and West Market Street.
- Provides alternative access to the airport from the west and south.
- Improves local access.

I-73 Connector

- Duplicates existing roadways that perform well today.
- Provides justification for Airport Connector.

Pleasant Ridge Relocation

- Warranted only after I-73 Connector and Airport Connector are built.
- Enhances local access.

I-73/74 Connector

- Arterial and Freeway options provide similar traffic benefits.
- Justified only after construction of the Airport Connector and/or Sandy Ridge Road Extension (North) and/or I-40 Connector.
- Will require additional improvements to local facilities serving the project.

I-40 Connector

- Traffic volumes and resulting benefits from this project are closely interrelated with other project decisions. The most significant interactions are associated with the widening of I-40, since these two projects share a substantial travel market. Combined with the Airport Connector and several road widening projects, the I-40 Connector could shift enough traffic off of I-40 to reduce or eliminate widen the segment between NC 68 and I-40 Bus. Conversely, if I-40 were to be widened, volumes on the I-40 Connector would be lower.

Airport Connector

- Arterial and Freeway options provide similar traffic benefits.

- Not justified until I-73/I-74 Connector, I-73 Connector, or I-40 Connector (or some combination) is built.

I-73 Connector Loop Roads

- Important for local access.
- Not justified until I-73 Connector and Airport Connector are built.

I-40 Widening

- Greatest benefit and greatest cost (as an individual project). However, some benefits in the study area (especially along I-40 between I-40 Bus and NC 68) can be obtained from other projects that shift traffic off of I-40. For example, building the I-40 Connector and the Airport Connector (combined with some other road widening) substantially lowers traffic on this portion of I-40, and could delay or eliminate the need for widening. On the other hand, completing the widening of I-40 could reduce the utility or demand for some of these (or other) projects.
- Difficult to construct while maintaining existing traffic patterns.

6.10 Other Considerations

The focus of this study involved the benchmarking and evaluation of project scenarios using traffic and cost information. While these two components are important factors influencing the selection and construction of roadway projects, they are by no means the only factors decision makers should consider. The following factors should be considered in concert with the results of this study:

- Local accessibility
- Changes in regional traffic patterns
- Goods movement
- Roadway network impact on development patterns
- Travel time changes to PTIA
- Enhancements to alternative modes

Greensboro Airport Area Modeling Study

December 2009

Prepared for the

Greensboro Urban Area

Metropolitan Planning Organization

MARTIN
ALEXIOU
BRYSON

Inside Front Cover

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Table of Contents

1 Executive Summary

1.1 Purpose

The purpose of the analysis is to revaluate the projects in the Piedmont Triad International Airport (PTIA) area. There are currently multiple combinations of twelve separate projects that could be constructed in the PTIA area. The technical evaluation of cumulative conditions in the PTIA area will support Greensboro Urban Area Metropolitan Planning Organization (GUAMPO) transportation system planning decisions. It will ensure that all previously identified project needs still exist and that the various proposed roadways in the area will meet these needs.

1.2 Project Scenario Analysis

The projects under consideration in the PTIA area were evaluated with the following travel demand model data and cost information:

- Projects – Number of individual projects included in each scenario, ranging from one to twelve.
- Cost (Million) – Total cost of the projects included in each scenario, in millions of dollars.
- VHD (Vehicle Hours of Delay) Reduction – Difference in VHD between each scenario and the base scenario (2035 E+C network, no scenario projects).
- VHD Reduction/Project – Total VHD reduction per number of projects included in each scenario.
- VHD Reduction/Cost (Million) – Total VHD reduction per scenario cost.

The above data was used to develop three implementation plan strategies for constructing the twelve projects.

1.3 Preferred Implementation Plan Strategy

As shown in Table 8, this implementation plan focuses on building projects in order of greatest incremental VHD reduction/cost, or the most effective projects per dollar spent. This strategy calls for the construction of local roadways before new freeway projects. This strategy is favorable from a VHD reduction/cost standpoint, because it produces a 1,250 VHD reduction (roughly 22% of the maximum) with the construction of the fifth project, for a cost of only $151.2 million. This strategy backloads the costs and requires an increment of $444.1 million between the tenth and eleventh projects. It should be noted that the "maximize VHD reduction/cost" strategy project sequence is very similar to the "minimize cost" strategy.

Table 1. Maximize VHD Reduction/Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pegg/Thatcher Street Connection	553	$ 23.4	23.6
3	Pleasant Ridge Road Widening	673	$ 36.7	18.3
4	Bryan Boulevard Loop	899	$ 74.4	12.1
5	I-73 Connector	1,250	$ 151.2	8.3
6	Pleasant Ridge Road Relocation	1,328	$ 166.1	8.0
7	Airport Connector	1,328	$ 189.2	7.0
8	I-40 Connector	2,209	$ 235.6	9.4
9	Sandy Ridge Road Extension (North)	2,299	$ 258.4	8.9
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11	NC 68 Widening	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

1.4 Comparison of Strategies

Ultimately, the balance of VHD reduction and cost performance is a very reasonable strategy, and if pursued would be defendable from a cost standpoint, while also resulting in traffic improvements in the PTIA area. Additionally, the "maximize VHD reduction/cost" strategy is best for minimizing future risk. While all three strategies have similar VHD reduction at the end of the implementation plan (if all twelve projects are constructed and is considered a complete system), the "maximize VHD reduction/cost" strategy is a conservative approach that incrementally builds the best returning project out of all remaining available projects.

Since funding or other factors may halt ultimate completion of any implementation plan, the "maximize VHD reduction/cost" strategy provides interim systems that work – projects constructed in the early stages of the implementation plan are not dependent on the later construction of other projects to realize the full value of earlier constructed projects. Therefore, a reasonable strategy is one that provides a desirable outcome at each interim stages of implementation, since the completion of the ultimate plan as currently envisioned cannot be guaranteed, due to unforeseeable changes in funding, growth and development, construction schedules, programming priorities, and other conditions.

2 Introduction

The Greensboro Urban Area Thoroughfare Plan (GUATP) includes important conceptual roadways near Piedmont Triad International Airport (PTIA). Many of the roadways were recommended as a part of the 2004 Triad International Airport Area Transportation Study. Major roadways resulting from the study include: Airport Connector (I-73/ I-74 Connector), I-40 Connector, and the Sandy Ridge Extension. Both connectors are identified as freeways, while Sandy Ridge Extension is a major thoroughfare.

Since the release of the GUATP by the Greensboro Urban Area Metropolitan Planning Organization (GUAMPO), additional planning studies have been conducted, including the Heart of the Triad Plan and the 2035 GUAMPO Long Range Transportation Plan (LRTP). Additionally, land in and around PTIA has been identified for airport and private development. Finally, the economic landscape has greatly changed within the last year and there is a greater emphasis on cost performance of major infrastructure investment projects. As such, GUAMPO decided to revaluate the planned roadway network near PTIA to ensure that the proposed roadways are needed and cost-effective.

It should be noted that PTIA is currently conducting a study of the Airport Area including the evaluation of roadways serving the airport. However, recommendations from the PTIA study were not available before the completion of this report.

2.1 Background

The Airport Area Transportation Study was completed by NCDOT in cooperation with the Triad MPOs and Piedmont Authority for Regional Transportation (PART). The recommended roadways noted above where added to the Greensboro Urban Area Thoroughfare Plan. The study also recommended the deletion of proposed projects shown on the Greensboro Thoroughfare Plan; they included the Sandy Ridge Road Connector from Sandy Ridge Road to Pleasant Ridge Road. This project was recommended for deletion as it was determined that the connection would result in an unacceptable LOS on Pleasant Ridge Road.

The study also recommended the deletion of the Joseph M. Bryan Boulevard Extension from NC 68 to Pleasant Ridge Road. It was recommended for deletion because it was believed the cost outweighed the benefit. However, the MPO decided to retain the proposed extension of Joseph M. Bryan Boulevard to Pleasant Ridge Road.

2.2 Purpose

The purpose of the analysis is to revaluate the projects in the PTIA area, including I-73/I-74 Connector, I-40 Connector, and Sandy Ridge Road Extension. There are currently multiple combinations of twelve separate projects that could be constructed in the PTIA area. The technical evaluation of cumulative conditions in the PTIA area will support GUAMPO transportation system planning decisions and ensure that all previously identified project needs still exist and that the various proposed roadways in the area will meet these needs. Additionally, the modeling work completed for this project will be used in support of the Sandy Ridge Road Widening and Extension Feasibility Study, currently underway.

2.3 Study Area

The PTIA is located in Guilford County, close to the Forsyth County border, and is bounded by Joseph M. Bryan Boulevard to the north, W. Market Street to the south, I-73 to the east, and NC 68 to the west. PTIA is located approximately 9 miles from downtown Greensboro, 11 miles from downtown High Point, and 16 miles from downtown Winston-Salem.

The study area for this project includes portions of the Piedmont Triad Region, which encompasses the Greensboro, Winston-Salem/Forsyth, High Point, and Burlington-Graham MPOs. The Piedmont Triad Regional Travel Demand Model (PTR TDM) covers all of the MPO boundaries, though only a subarea of the total model, described as the PTIA area within this report, was utilized for detailed traffic analysis.

This study area was selected for purposes of traffic forecasting because the projects in the PTIA area have the potential to draw traffic from the local surface streets, which are often congested during the peak periods. The project study area covers a larger extent than the actual roadway improvement design limits because it is necessary to examine the regional effects of traffic diversion through the area. Figures 1 and 2 show the extents of the PTR TDM and the PTIA area (shown in black), respectively.

Figure 1. Piedmont Triad Regional Travel Demand Model Extents

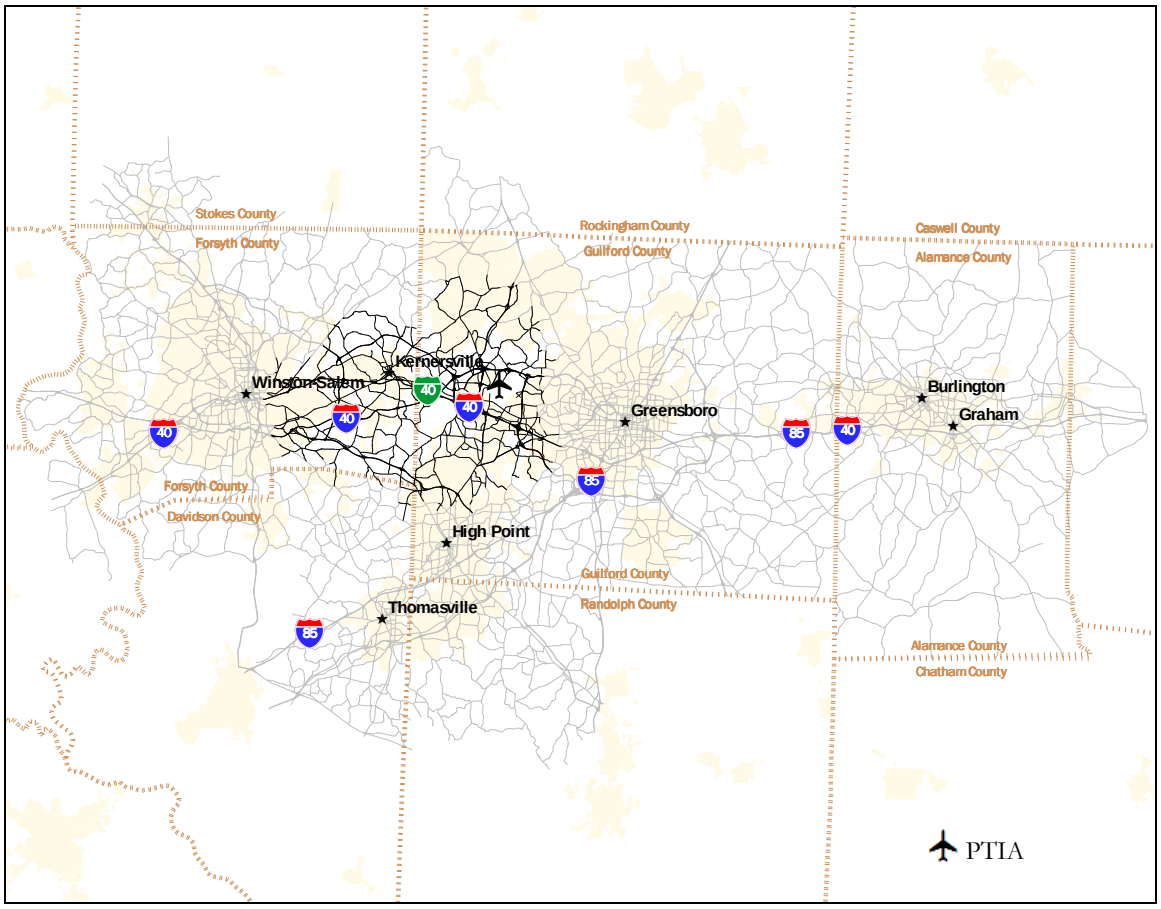
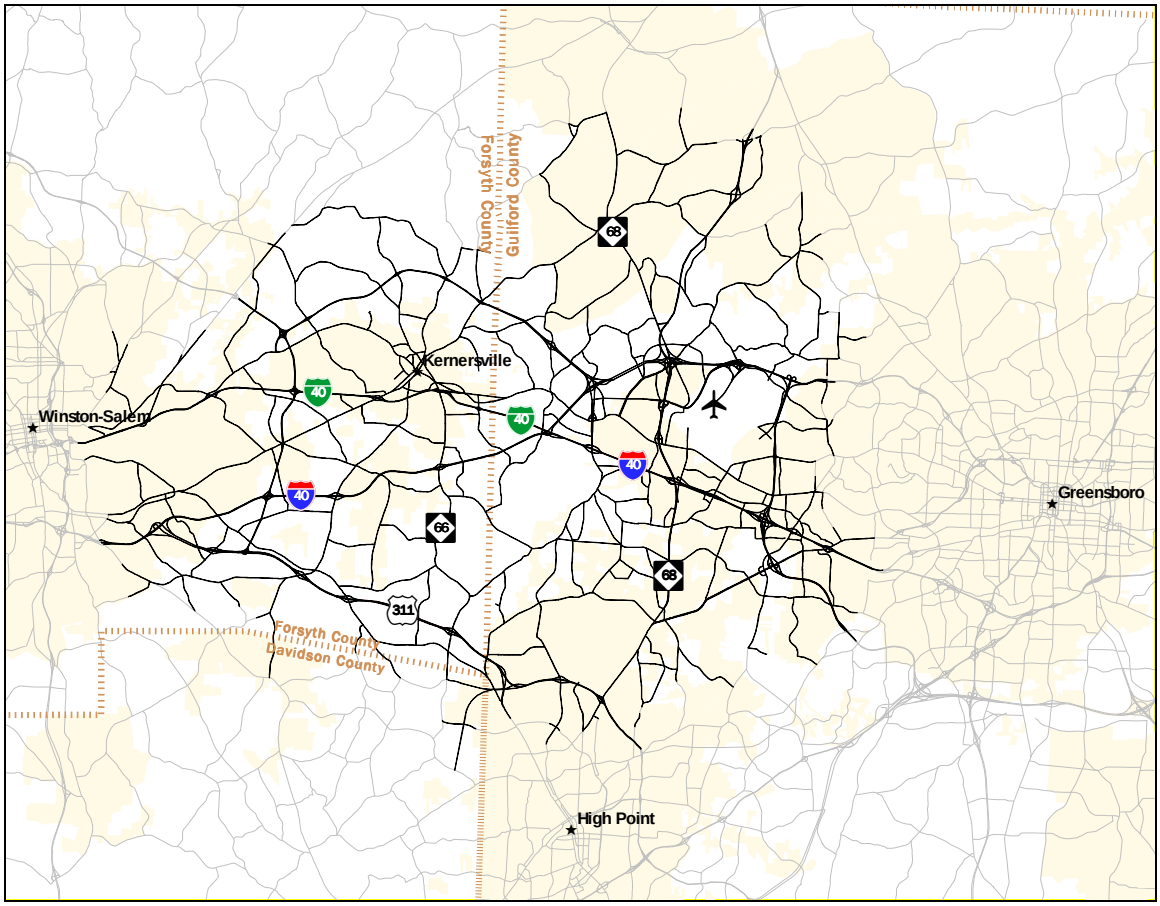


Figure 2. Piedmont Triad Airport Subarea Model Extents



2.4 Study Oversight

GUAMPO staff guided this study, though the following stakeholder group was consulted throughout the project:

- City of Greensboro Planning and Engineering
- City of High Point DOT
- City of Winston-Salem Planning and Engineering
- Town of Kernersville Public Works Department
- Piedmont Triad International Airport Authority
- Greensboro Metropolitan Planning Organization
- Winston-Salem Forsyth Metropolitan Planning Organization
- High Point Metropolitan Planning Organization
- Piedmont Authority for Regional Transportation
- North Carolina Department of Transportation

3 Projects Under Evaluation

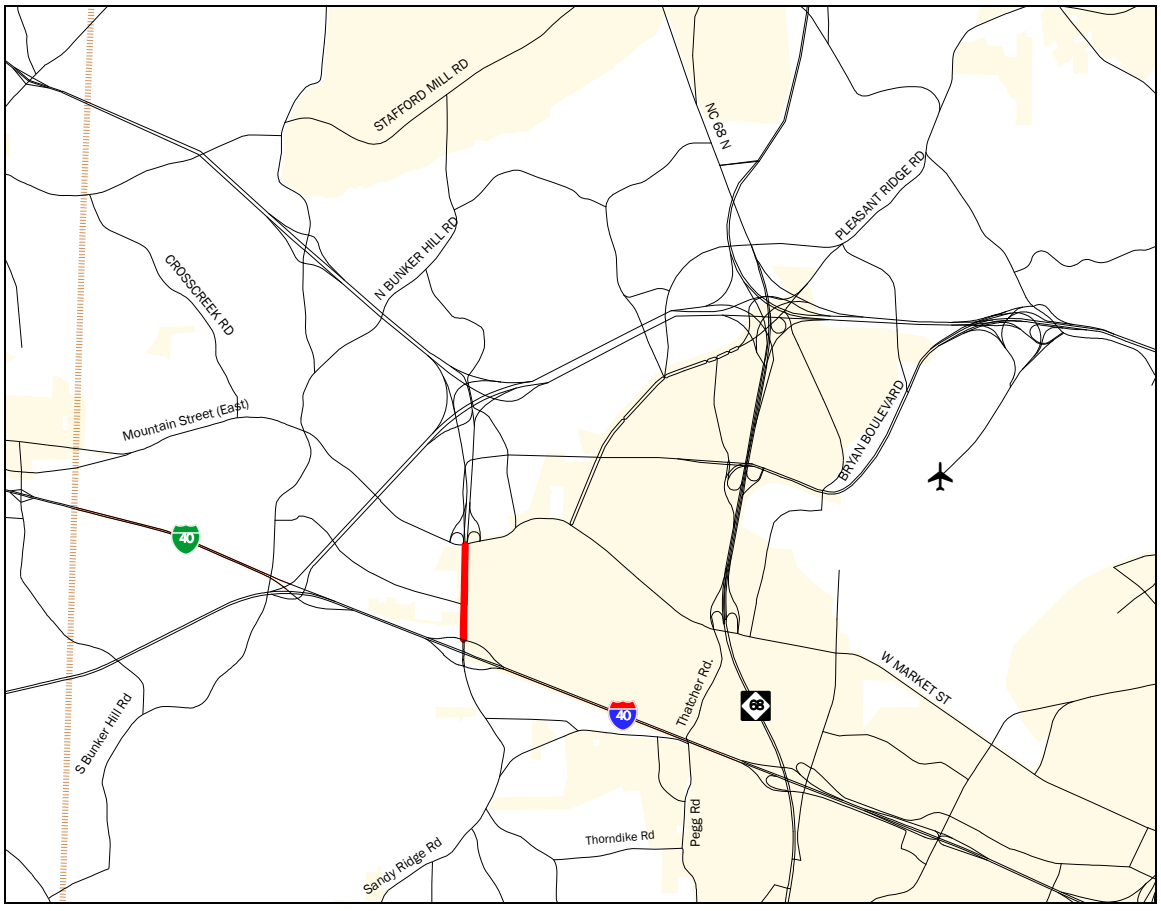
For this study, twelve projects are under consideration, some with multiple alternatives, as detailed in the following sections. Each project is designated by a letter (A-G) and a number (if there are multiple design options). Cost estimates (right of way and construction) for each project and design option are taken from the GUAMPO and WSMPO 2035 LRTPs, NCDOT feasibility studies, and NCDOT cost estimation sheets.

3.1 Sandy Ridge Road Widening

This project involves widening Sandy Ridge Road between I-40 and West Market Street. The existing Sandy Ridge Road is a collector road with one lane in each direction and no median. The proposed project widens this segment to two lanes in each direction with a median. The location of the Sandy Ridge Road widening project is shown in red on Figure 3.

- Project A1 – Existing Sandy Ridge Road – $0
- Project A2 – Widened Sandy Ridge Road – $5,554,852

Figure 3. Sandy Ridge Road Widening Project Extents

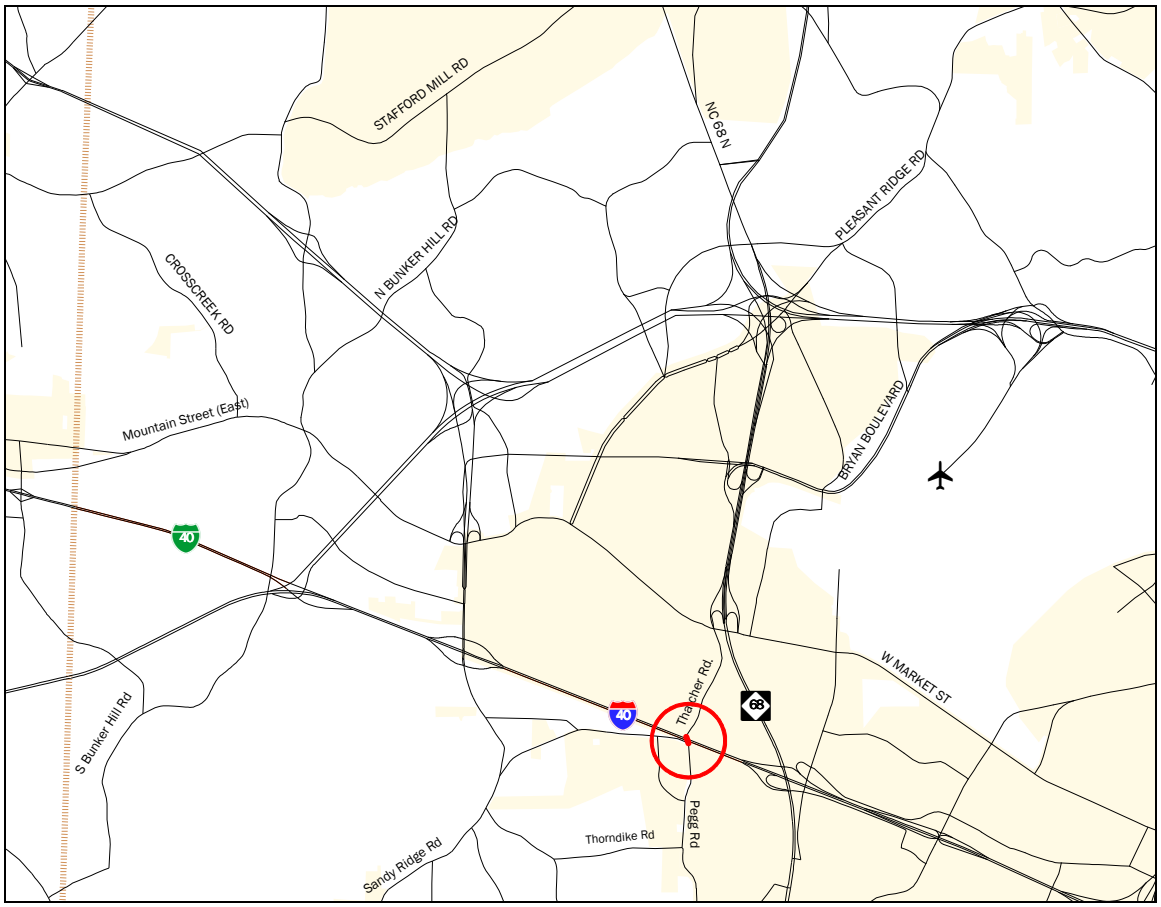


3.2 Pegg Road/Thatcher Road Connector

This project involves construction of a new facility to connect Pegg Road and Thatcher Road, which are currently separated by I-40. The proposed project adds a collector street with two lanes in each direction and a median that provides connectivity via a bridge over I-40. The location of the Pegg Road/Thatcher Road Connector project is shown in red on Figure 4.

- Project B – Pegg Road/Thatcher Road Connector – $17,855,910

Figure 4. Pegg Road/Thatcher Road Connector Project Extents

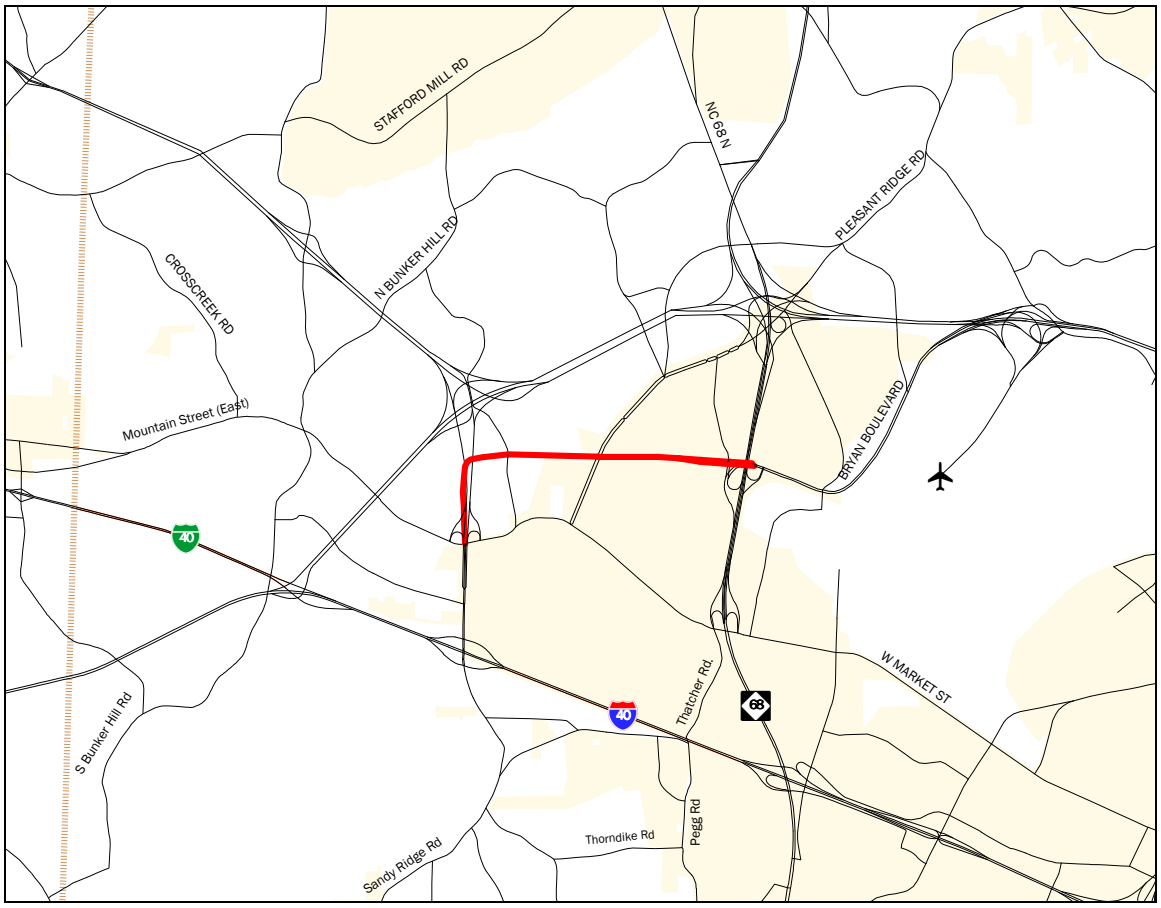


3.3 Sandy Ridge Road Extension

This project involves construction of a new facility to extend Sandy Ridge Road to either: 1) Bryan Boulevard (Eastern Extension) or 2) the proposed I-40 Connector (Northern Extension). The proposed Eastern Extension project is an arterial street with two lanes in each direction and a median that connects to Bryan Boulevard at an interchange with NC 68. The proposed Northern Extension project is a divided roadway with two lanes in each direction that connects to the proposed I-40 Connector at an interchange with the proposed I-73/I-74 and Airport Connectors. The location of the Sandy Ridge Road Extension projects are shown in red on Figures 5 (Eastern Extension) and 6 (Northern Extension).

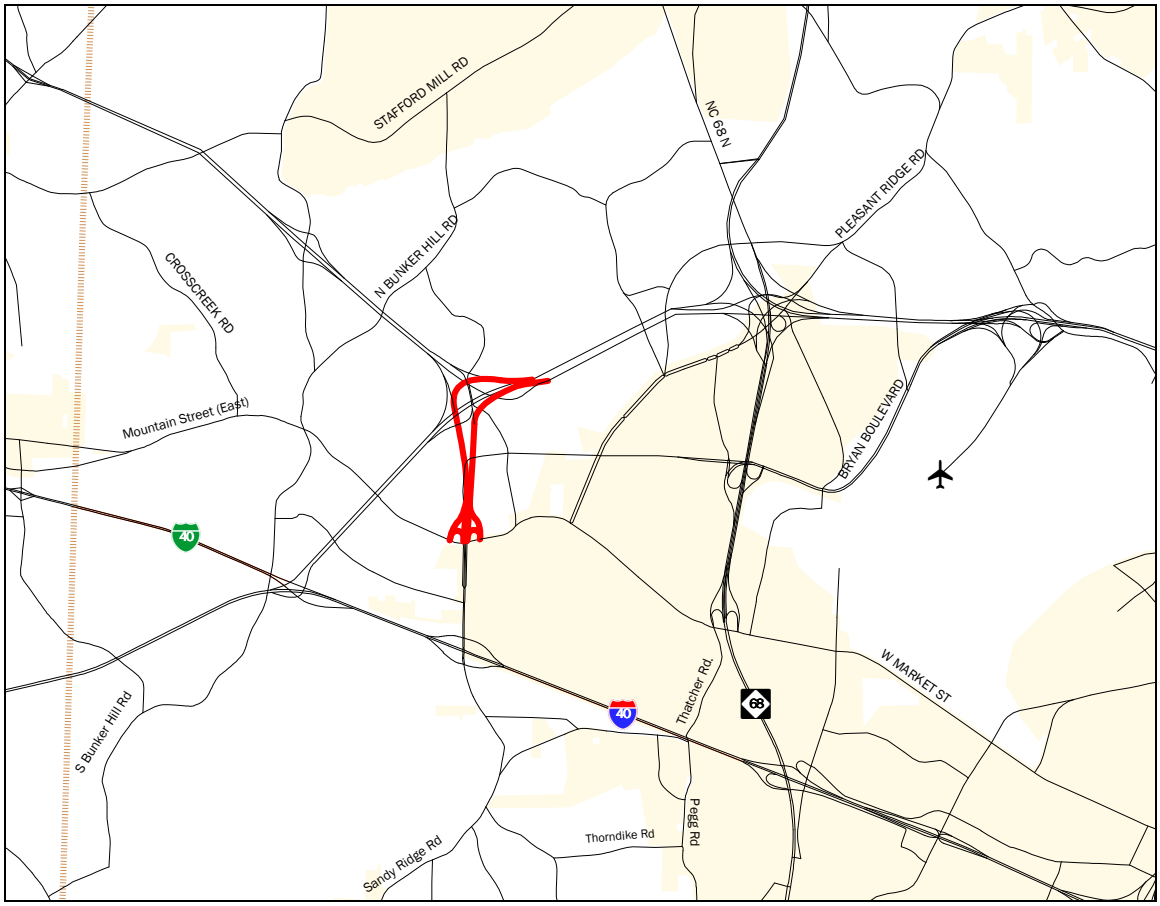
Modeling and analysis of both Sandy Ridge Road extension alternatives assumed a grade separation at West Market Street. An at-grade intersection could also be considered (either as an interim stage or as a final design), yielding substantial right-of way and construction savings.

Figure 5. Sandy Ridge Road Eastern Extension Project Extents



- Project C1 – Sandy Ridge Road Eastern Extension – $40,000,000
- Project C2 – Sandy Ridge Road Northern Extension – $22,768,800

Figure 6. Sandy Ridge Road Northern Extension Project Extents

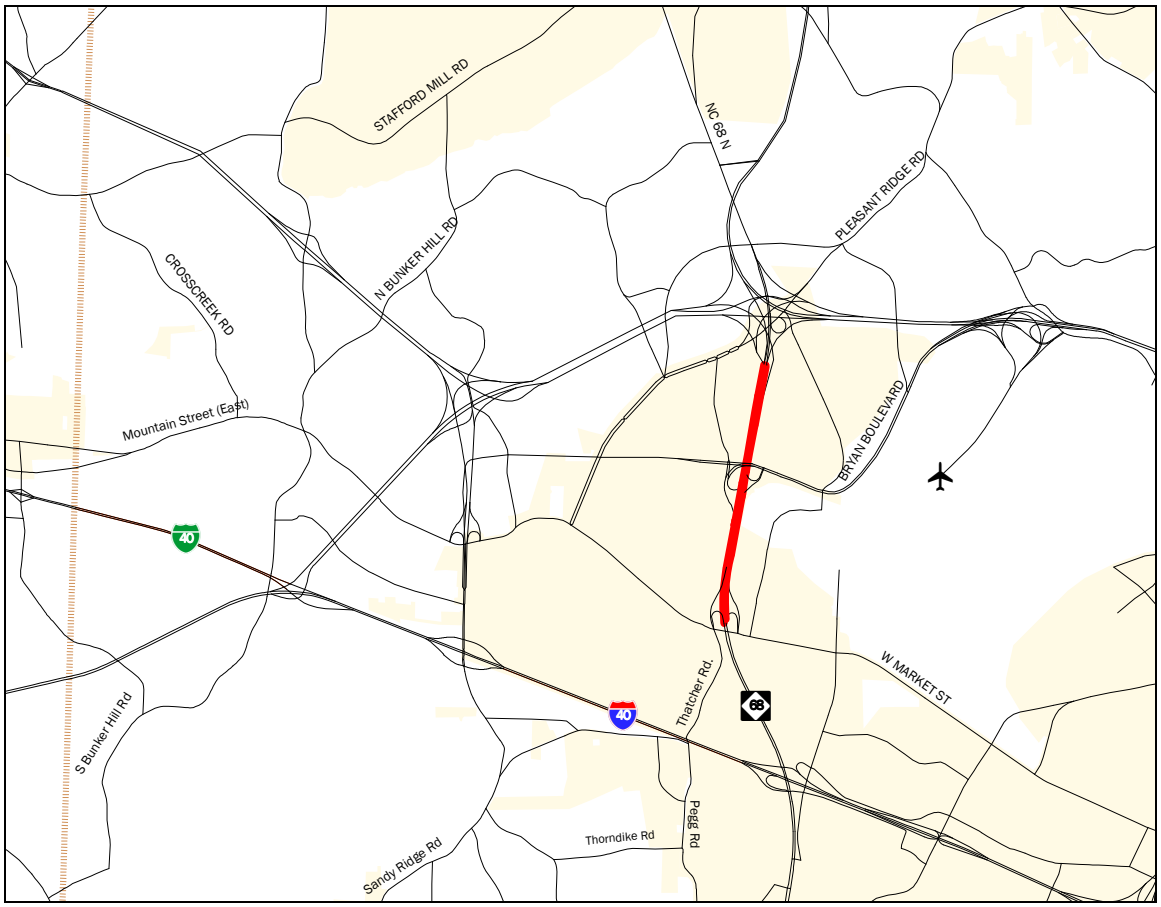


3.4 NC 68 Widening

This project involves widening a portion of NC 68 between West Market Street and Pleasant Ridge Road. The existing NC 68 is a divided highway with two lanes in each direction. The proposed project widens this section to four lanes in each direction. The location of the NC 68 widening project is shown in red on Figure 7.

- Project D1 – Existing NC 68 – $0
- Project D2 – Widened NC 68 – $58,114,585

Figure 7. NC 68 Widening Project Extents

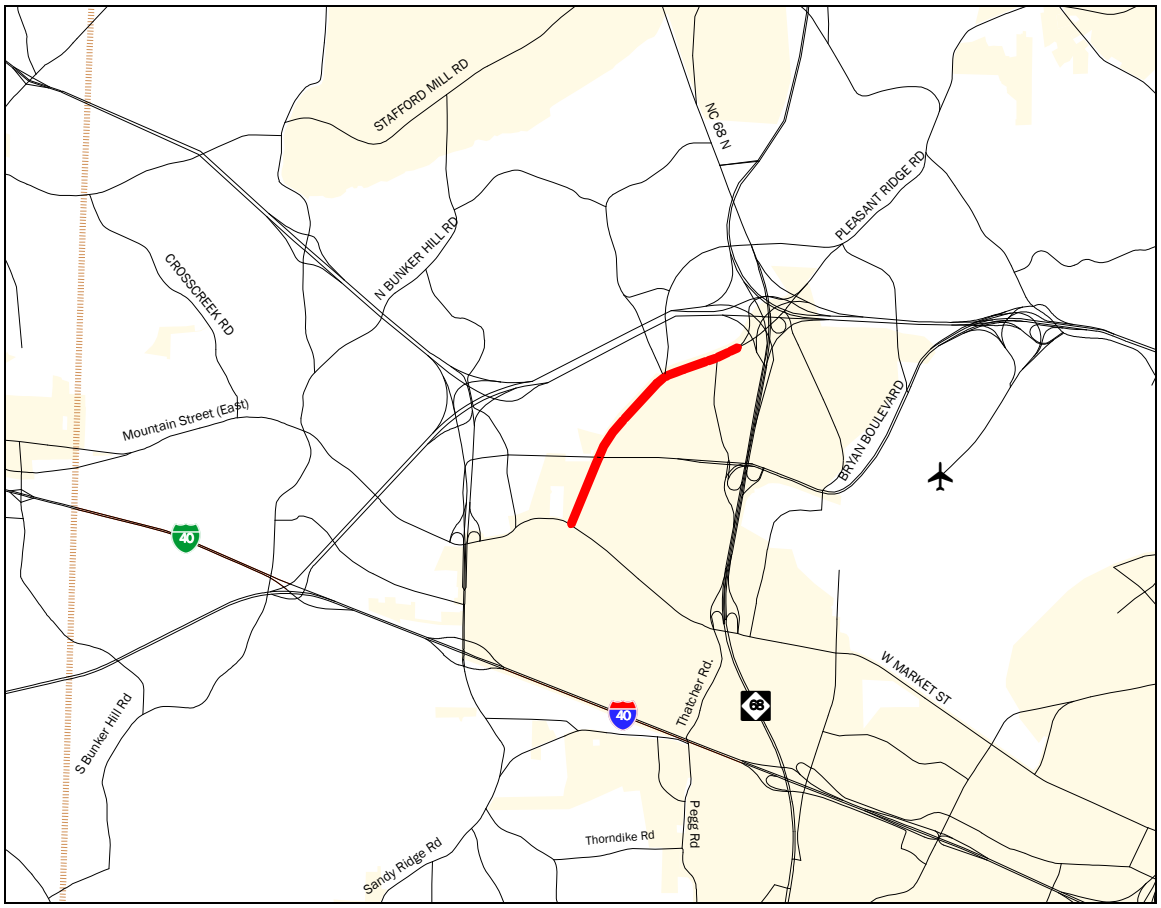


3.5 Pleasant Ridge Road Widening

This project involves widening a portion of Pleasant Ridge Road between West Market Street and Edgefield Road. The existing Pleasant Ridge Road is a rural road with one lane in each direction and no median. The proposed project widens this segment to two lanes in each direction with a median. The location of the Pleasant Ridge Road widening project is shown in red on Figure 8.

- Project E1 – Existing Pleasant Ridge Road – $0
- Project E2 – Widened Pleasant Ridge Road – $13,275,000

Figure 8. Pleasant Ridge Road Widening Project Extents

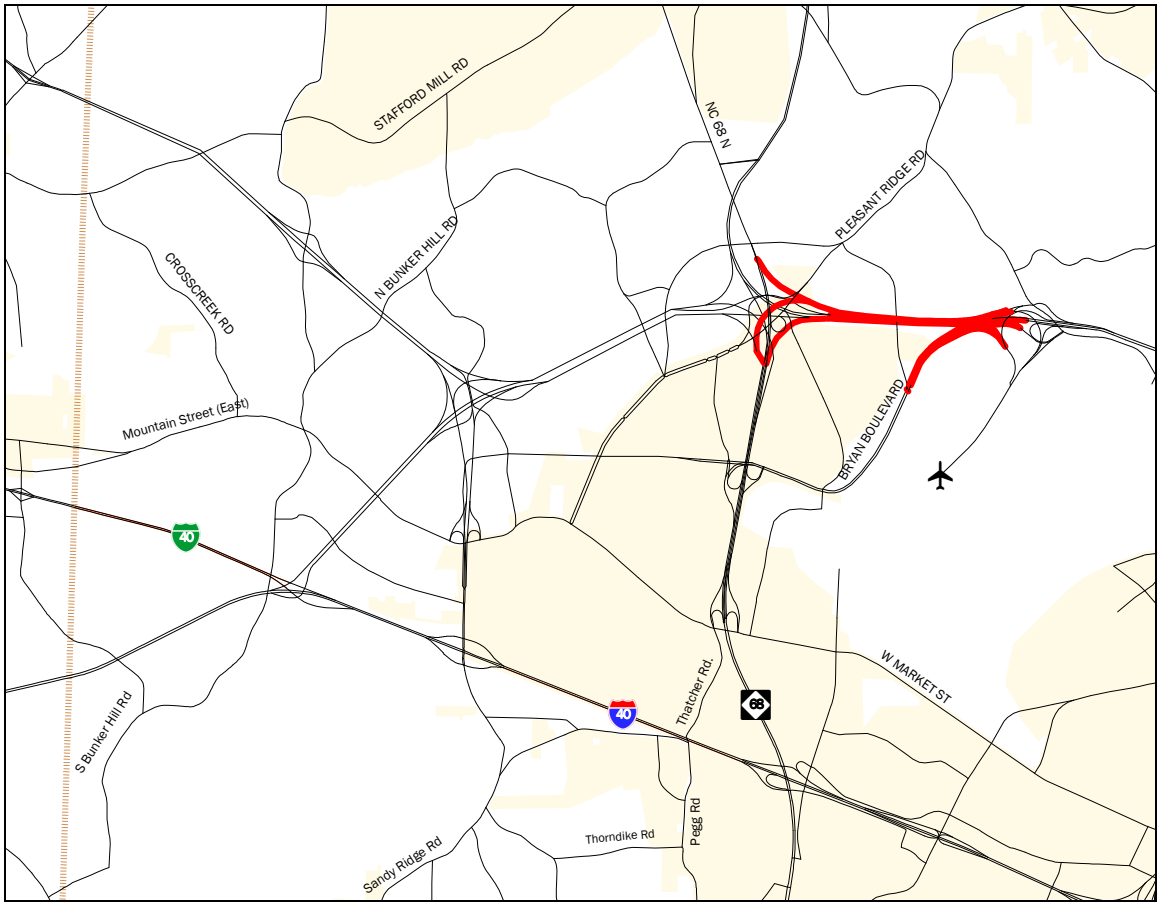


3.6 I-73 Connector

This project involves constructing a new facility between Joseph M. Bryan Boulevard and the future I-73. The proposed project is a divided freeway with two lanes in each direction. The proposed project also includes the removal of a portion of Bryan Boulevard between Caindale Drive and Old Oak Ridge Road. Additionally, the proposed project connects to the future I-73 at an interchange with NC 68 and the proposed Airport Connector. The location of the I-73 Connector project is shown in red on Figure 9.

- Project F1 – Existing Joseph M. Bryan Boulevard – $0
- Project F2 – I-73 Connector – $76,813,560

Figure 9. I-73 Connector Project Extents

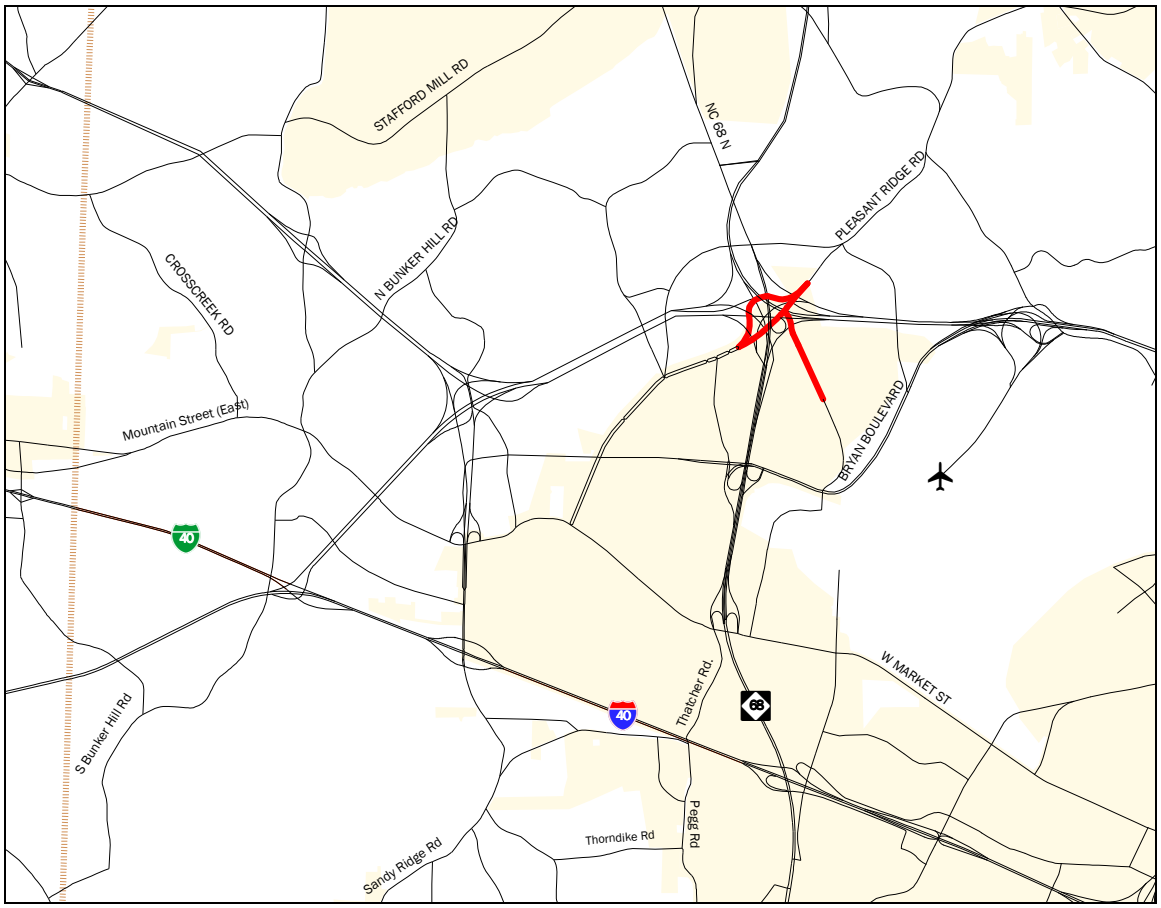


3.7 Pleasant Ridge Road Relocation

This project involves relocating a portion of Pleasant Ridge Road between Brigham Road and North Regional Road to make room for the future I-73/NC 68 interchange. The existing Pleasant Ridge Road is a rural road with one lane in each direction and no median. The proposed project widens the section to two lanes in each direction with a median located north of the current alignment. The project will have an at-grade intersection with NC 68. The location of the Pleasant Ridge Road relocation project is shown in red on Figure 10.

- Project G1 – Existing Pleasant Ridge Road – $0
- Project G2 – Relocated Pleasant Ridge Road – $14,869,268

Figure 10. Pleasant Ridge Road Relocation Project Extents



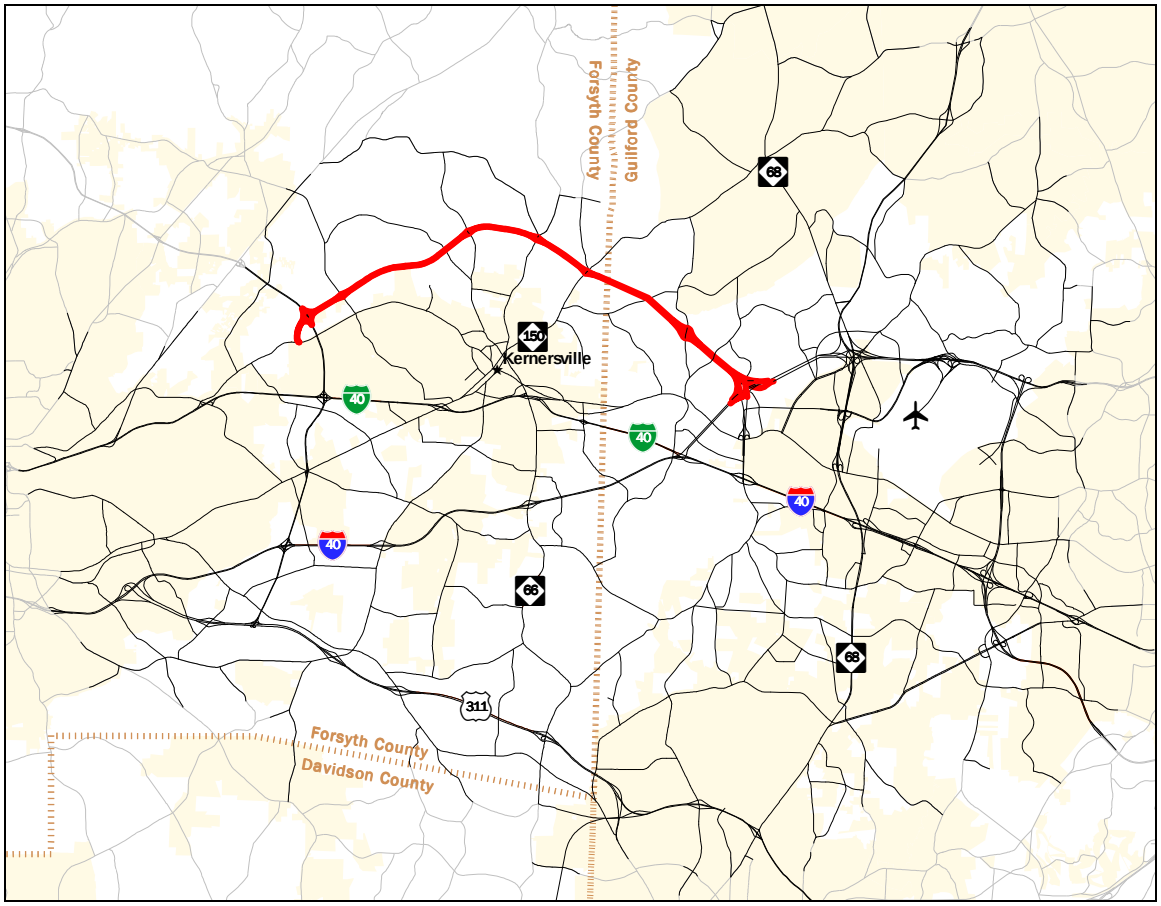
3.8 I-73/I-74 Connector

This project constructs a new facility, also known as the Kernersville Bypass, between West Mountain Street in Winston-Salem and the proposed Airport Connector. The proposed project has two options: 1) a divided freeway with two lanes in each direction or 2) an arterial street with two lanes in each direction and a median. The arterial version substitutes at-grade intersections for five of the seven interchanges in the freeway version, retaining the interchanges at the eastern and western termini.

This project connects to the proposed Airport Connector at an interchange with the proposed I-40 Connector and the Northern Sandy Ridge Road Extension. Note that the cost of this interchange is associated with the I-73/I-74 Connector project, not with the I-40 Connector, as assumed in the GUAMPO LRTP. This change was made to more accurately associate costs with the most appropriate project, given the segmentation of the Airport Connector in this analysis, and the variety of project combinations being assessed. The location of the I-73/I-74 Connector project is shown in red on Figure 11.

- Project H1 – Freeway I-73/I-74 Connector – $388,023,400
- Project H2 – Arterial I-73/I-74 Connector – $314,793,400

Figure 11. I-73/I-74 Connector Project Extents

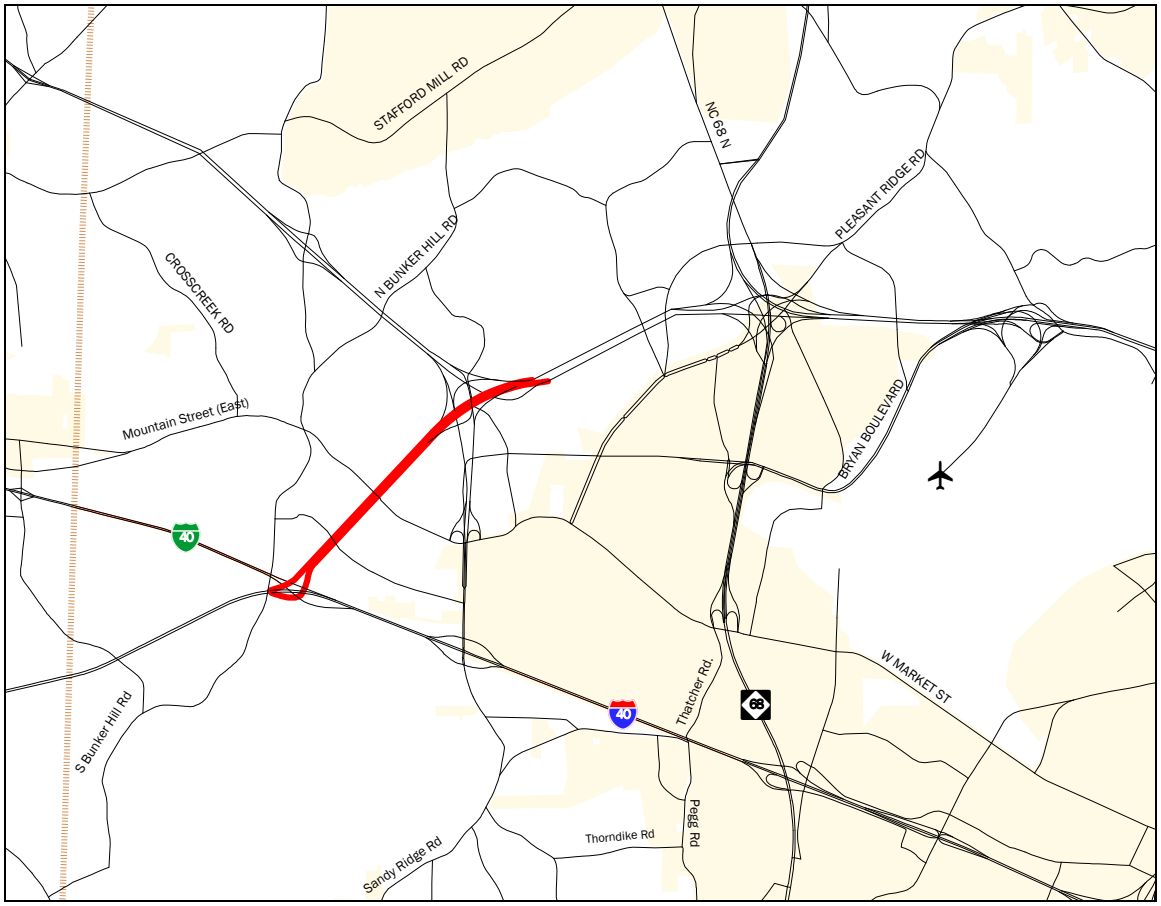


3.9 I-40 Connector

This project involves constructing a new facility between I-40 and the proposed Airport Connector. The proposed project is a divided freeway with two lanes in each direction and also includes the expansion of the I-40/Business I-40 interchange. The proposed project connects to the proposed Airport Connector at an interchange with the proposed I-73/I-74 Connector and Northern Sandy Ridge Road Extension. Note that while the GUAMPO LRTP attributes the cost of this interchange to the I-40 Connector, this analysis associates the cost of the interchange with the I-73/I-74 Connector project. Given the segmentation of the Airport Connector in this analysis, and the variety of project combinations being assessed, this change appears to more accurately associate costs with the most appropriate project. The location of the I-40 Connector project is shown in red on Figure 12.

- Project I – I-40 Connector – $46,354,000

Figure 12. I-40 Connector Project Extents

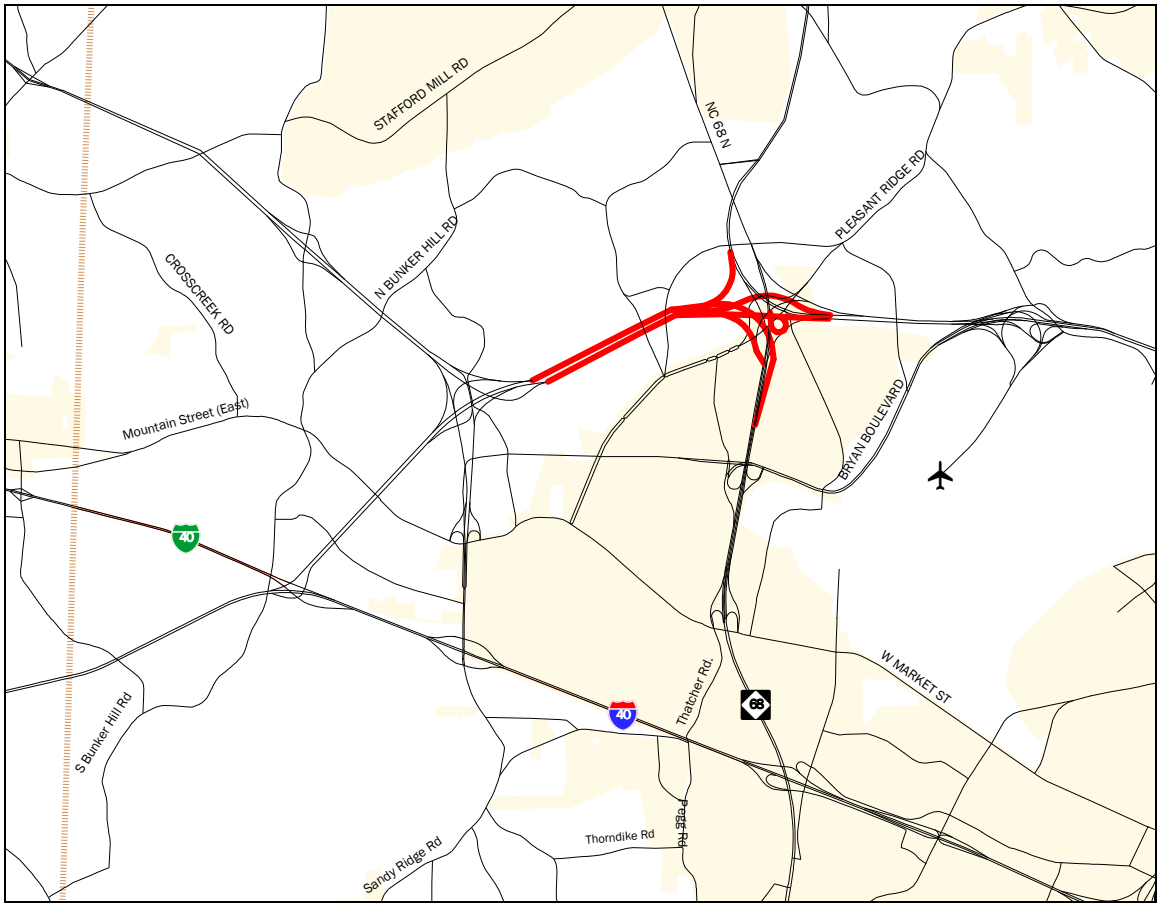


3.10 Airport Connector

This project constructs a new facility between the proposed I-73/I-74 Connector and the proposed I-73 Connector. The proposed project is a divided freeway with two lanes in each direction. This project connects to the proposed I-73/I-74 Connector at an interchange with the proposed I-40 Connector and Northern Sandy Ridge Road Extension. (As previously discussed, the cost of this interchange is associated with the I-73/I-74 Connector). Additionally, the proposed project also connects to the proposed I-73 Connector at an interchange with NC 68 and the future I-73. The location of the Airport Connector project is shown in red on Figure 13.

- Project J1 – Freeway Airport Connector – $23,125,600

Figure 13. Airport Connector Project Extents

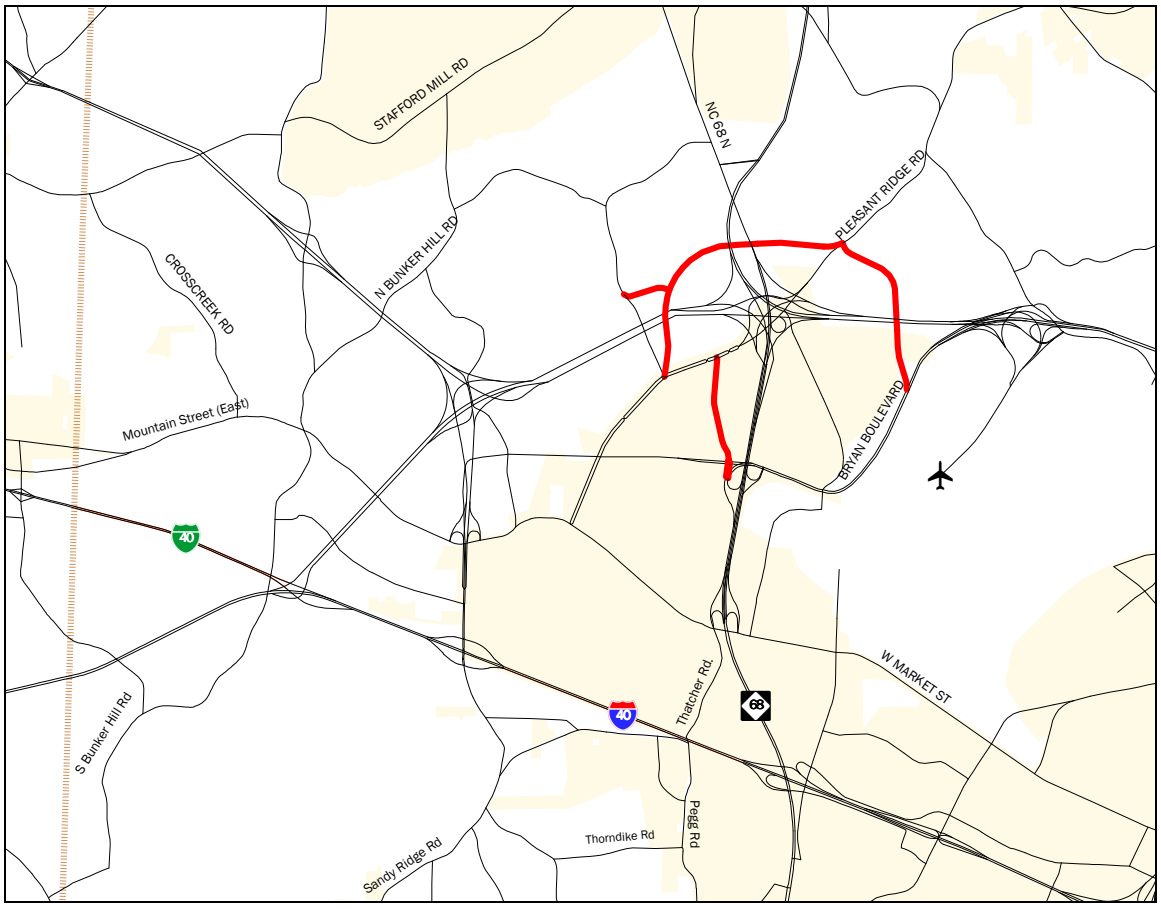


3.11 I-73 Connector Loop Roads

This project involves construction of new facilities to provide local access roads around the future I-73/proposed I-73 Connector/NC 68/proposed Airport Connector interchange. The proposed facilities are rural roads with one lane in each direction and no median. The proposed facilities will connect Joseph M. Bryan Boulevard to Pleasant Ridge Road, Pleasant Ridge Road north of the proposed I-73 Connector to Pleasant Ridge Road south of the proposed Airport Connector, and Pleasant Ridge Road south of the proposed Airport Connector to the proposed Eastern Sandy Ridge Road Extension at the Joseph M. Bryan Boulevard/NC 68 interchange. The location of the I-73 Connector Loop Roads project is shown in red on Figure 14.

- Project K – I-73 Connector Loop Roads – $37,748,635

Figure 14. I-73 Connector Loop Roads Project Extents

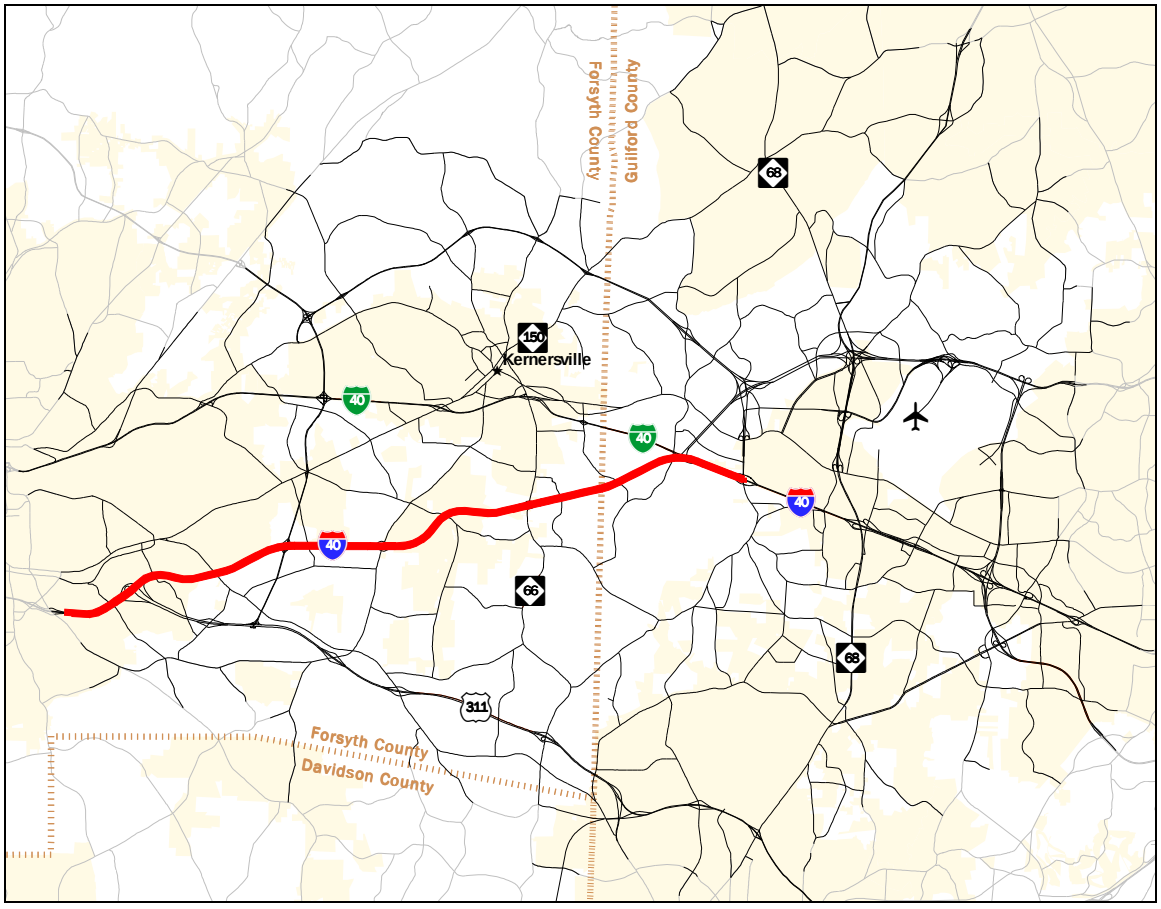


3.12 I-40 Widening

This project involves widening a portion of I-40 between NC 109 in Thomasville and NC 68 in Greensboro. Existing I-40 is a divided freeway with two lanes in each direction between NC 109 and the I-40/Business I-40 interchange and four lanes in each direction between the I-40/Business I-40 interchange and NC 68. The proposed improvements include widening to four lanes in each direction between NC 109 and the I-40/Business I-40 interchange, and widening to five lanes in each direction between the I-40/Business I-40 interchange and NC 68. The proposed project also adds loop ramps at the Old Salem Road/I-40 and Sandy Ridge Road/I-40 interchanges. The location of the I-40 widening project is shown in red on Figure 15.

- Project L1 – Existing I-40 – $0
- Project L2 – Widened I-40 – $444,100,000

Figure 15. I-40 Widening Project Extents



3.13 Evaluation Scenarios

There are 9,214 possible project scenarios, representing every possible combination of the twelve projects, ranging from solely widening Sandy Ridge Road to constructing all of the new projects listed above. The purpose of evaluating all combinations is to understand the cumulative travel benefits of individual projects, as well interactions among multiple projects. For example, both the Sandy Ridge Road widening and Extension projects may have individual benefits, but when constructed in combination, they may have even greater benefit.

4 Travel Demand Model Review

A critical component of the traffic analysis for this project is the preparation of year 2035 subarea traffic forecasts for project scenario testing. Because results from this study will be used for the Sandy Ridge Feasibility Study, it is important that the subarea traffic forecasting approach be consistent with adopted regional data and procedures. This chapter documents the approach for developing year 2035 subarea traffic forecasts using the TransCAD software package.

4.1 Use of the Piedmont Triad Regional Travel Demand Model

A key input into the process is the 2002 approved version of the Piedmont Triad Regional Travel Demand Model. This model utilizes the TransCAD software platform along with recent land use and road network information to forecast the regional demand to 2035. The base year model is calibrated for 2002 conditions and the forecast year model represents 2035 conditions. The model was developed for the entire Piedmont Triad Regional area and includes detailed zone and network systems within Forsyth, Guilford, and Alamance Counties. The model also includes portions of Davidson and Randolph Counties.

4.2 Land Use Assumptions

One of the primary inputs for the PRT TDM is land use data, which is used to estimate trip generation information. Land use information is summarized within traffic analysis zones (TAZs), which represent geographical boundaries that contain many individual parcels. The PRT TDM employs eight land use data categories for each TAZ:

- Households
- School Students
- Highway Retail Employees
- Industrial Employees
- Retail Employees
- Service Employees
- Office Employees
- School Employees

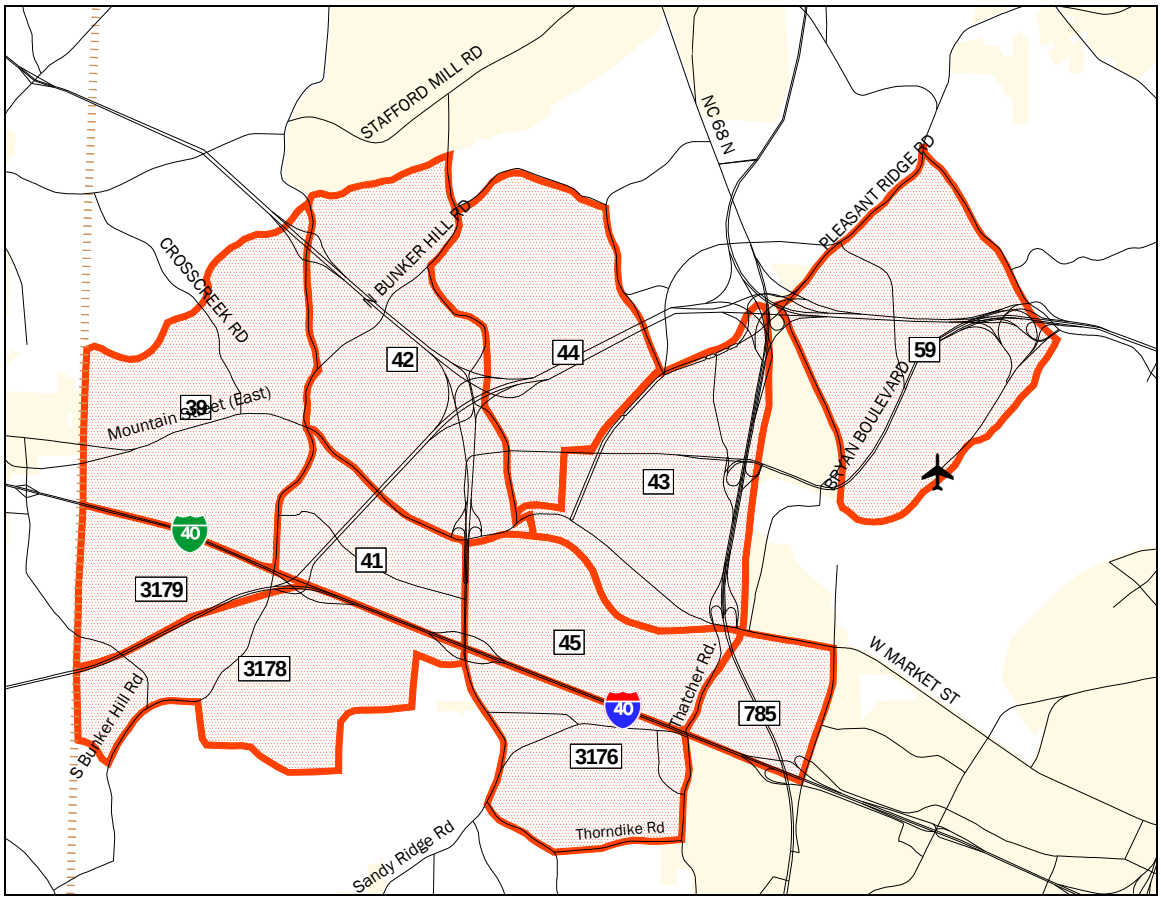
For the purposes of this study, the land use data contained in the approved 2009 and 2035 Existing + Committed (E+C) scenarios was used. However, the land use forecast within the PTIA area was thoroughly reviewed by GUAMPO staff and adjusted to account for recent development proposals that could significantly affect the future transportation network planning in the area.

GUAMPO staff recommended changes within the PTIA area, which were included in the land use assumptions for the 2035 model runs, as shown in Table 2 and Figure 16:

Table 2. 2035 Land Use Changes

TAZ	HH	HWY RET	IND	RETAIL	SERVICE	OFFICE	SCHOOL
Existing 2035 Data							
39	0	0	438	21	61	57	0
41	92	412	0	260	391	0	0
42	467	9	509	147	561	0	107
43	0	0	3,329	430	1,318	0	0
44	407	26	432	225	232	84	0
45	0	141	2,714	3,046	1,096	1,298	0
59	0	39	2,887	1,064	3,256	1,662	0
785	0	0	2,124	1,667	3,024	433	0
3176	0	0	634	2,749	1,386	463	0
3178	0	193	7	514	1,181	50	0
3179	0	0	0	0	0	0	0
Land Use Changes							
39	0	0	+380	+18	+53	+49	0
41	+500	+2,294	0	+1,448	+2,178	0	0
42	-300	+17	+966	+279	+1,065	0	+203
43	0	0	-1,134	-146	-449	0	0
44	-200	+66	+1,094	+570	+587	+213	0
45	0	-60	-1,146	-1,287	-463	-548	0
59	0	-9	-648	-239	-731	-373	0
785	0	0	-1,245	-977	-1,772	-254	0
3176	0	0	-12	-53	-26	-9	0
3178	0	-10	0	-26	-61	-3	0
3179	0	0	+100	+64	+30	+6	0
Airport Area Study 2035 Data							
39	0	0	818	39	114	106	0
41	592	2,706	0	1,708	2,569	0	0
42	167	26	1,475	426	1,626	0	310
43	0	0	2,195	284	869	0	0
44	207	92	1,526	795	819	297	0
45	0	81	1,568	1,759	633	750	0
59	0	30	2,239	825	2,525	1,289	0
785	0	0	879	690	1,252	179	0
3176	0	0	622	2,696	1,360	454	0
3178	0	183	7	488	1,120	47	0
3179	0	0	100	64	30	6	0

Figure 16. 2035 Land Use Changes TAZ Map



4.3 Roadway Network Assumptions

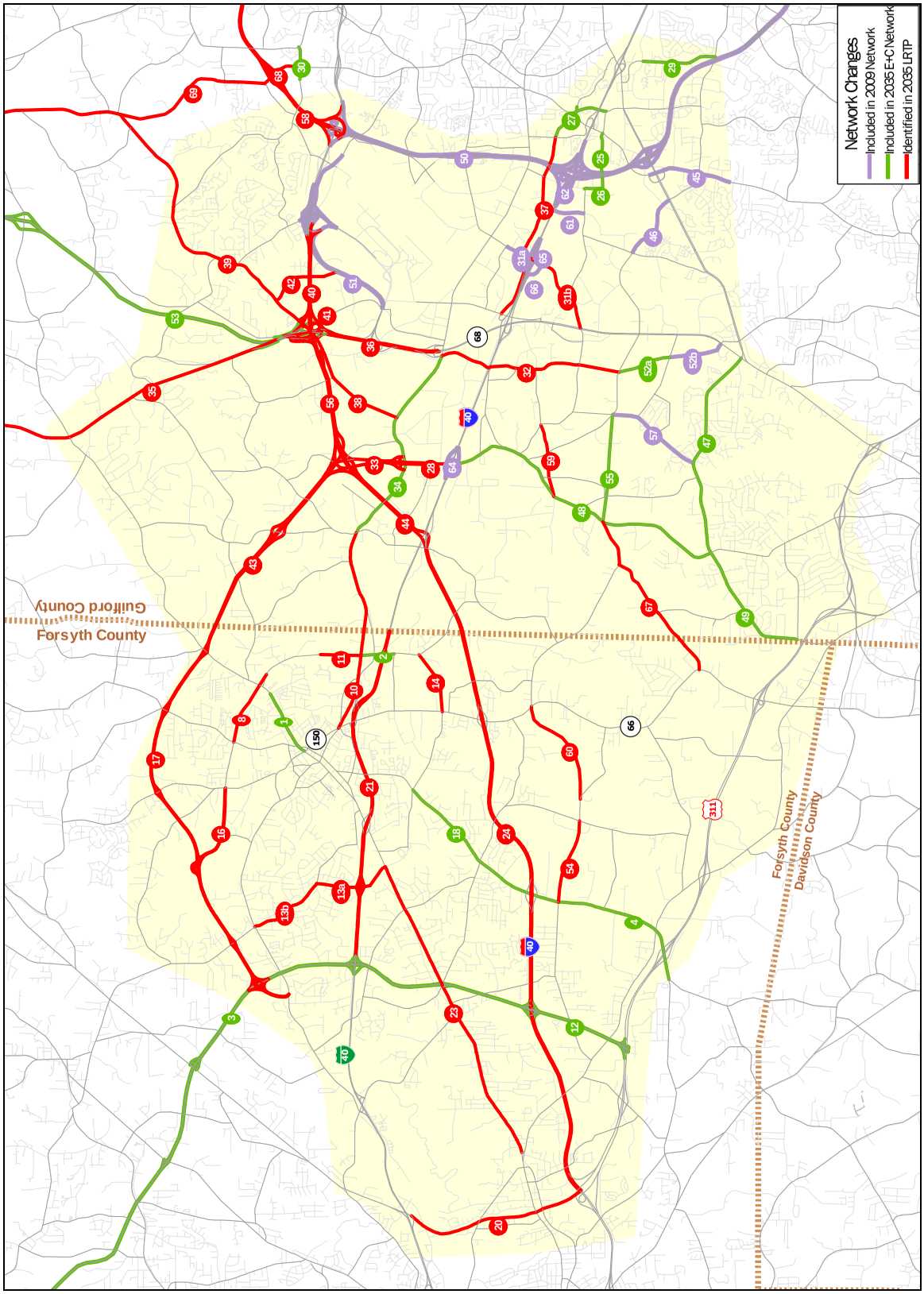
The roadway network for the 2009 and 2035 E+C conditions is based on the 2008 approved model roadway centerline file. The model roadway networks include all state routes, arterials, collectors, and important local roads within the study area. The roadway network database includes street name, distance, and generalized functional class. In addition to these attributes, speed, capacity, number of lanes, median presence, and signals per mile were coded. The roadway attributes are used by the travel demand model to estimate the vehicular capacity for each roadway segment.

The 2009 model roadway network represents existing conditions and includes only roadways operational in 2009. The 2035 E+C model roadway network includes both existing roadways and roadway projects with funding commitments that are anticipated to be operational by 2035. There are a number of proposed roadway improvements in the PTIA area that are accommodated in the forecasting process based on input from the Steering Committee. The Piedmont Triad Regional Travel Demand Model was inspected and modified to ensure that the 2035 roadway network included the improvements listed in Table 3 and shown on Figure 17. Projects identified in the area 2035 LRTPs are also listed in the table and figure, which include the twelve projects under evaluation in the PTIA area.

Table 3. Network Changes Description

ID	Project Name	Project Limits	Existing	Proposed
		Included in 2009 Network		
31a	Gallimore Dairy Road	International Drive to Albert Pick Rd	2 lane	4 lane divided
45	Guilford College Road (SR 1546)	High Point Rd (SR 4121) to south of Wendover Ave (SR 1541)	2 lane	4 - 5 lane
46	Piedmont Parkway Extension	Tarrant Road to W. Wendover Avenue		4 lane divided
50	I-840	Bryan Boulevard to I-85		6 lane freeway
51	Bryan Boulevard Extension / Relocation	Old Oak Ridge Road to Regional Road		4 lane freeway
52b	Penny Road	NC 68 to Willard Dairy Road		4 lane divided
57	Barrow Road	Clinard Farms Road to Skeet Club Road		4 lane divided
61	Boulder Road	Chimney Rock Road to Burnt Poplar Rd		2 lane undivided
62	Chimney Rock Road	Hornaday Road Extension to Burnt Poplar Rd	2 lane	remove road
64	Sandy Ridge Road Ramps to I-40	I-40 at Sandy Ridge Road	ramps	standard diamond
65	Gallimore Dairy Road Ramps to I-40	I-40 at Gallimore Dairy Road		diamond and butterfly ramps
66	Albert Pick Road	Albert Pick Road to Gallimore Dairy Road (relocation)	2 lane	2 lane undivided
		Included in 2035 E+C Network		
1	North Main Street (NC 150)	NC66 to Clay Flynt Road		3 lane
2	SR 2601 (Macy Grove Road)	New Location and Convert Grade Separation at I-40 Business to an Interchange.		Build Interchange ; 4 lane divided
3	74)	(Reidsville Road)		New 4 - 6 lane freeway
4	Union Cross Road (SR 2643)	I-40 to High Point Road	2 lane	3 lane and 4 lane divided
12	74)	(Reidsville Road) to US 52)		New 4-6 lane divided
18	Union Cross Road (SR 2643)	Widening from Wallburg Road (SR 2691) to Whicker Road (SR 2640)	2-3 lane	4 lane divided
25	Hornaday Road Extension	Hornaday Road to Chimney Rock Road		3 lane
26	Hornaday Road Bridge	Grade Separation over Greensboro Urban Loop		3 lane
27	Bridford Parkway Extension	Hornaday Road to Burnt Poplar Road		4 lane divided
29	Stanley Road	Koger Boulevard to Hilltop Road	2 lane	5 lane
30	Horsepen Creek Rd / Fleming Rd Connector	Isaacson Boulevard to Inman Road		4 lane divided
34	West Market Street	Bunker Hill Road to NC 68	2 lane	4 lane divided
47	Skeet Club Road	NC 68 to Johnson Street	2 lane	4 - 5 lane
48	Johnson Street/Sandy Ridge Road	Skeet Club Road to I-40	2 lane	4 lane divided
49	Skeet Club Road	Johnson Street to US 311	2 lane	4 - 5 lane
52a	Penny Road	Willard Dairy Road to Clinard Farms Road		4 lane divided
53	NC 68 / US 220 Connector	NC 68 to US 220		4 lane freeway
55	Piedmont Parkway Extension	Johnson Street to Barrow Road		4 lane divided
		Identified in 2035 LRTP		
8	N. Main St./Piney Grove Rd. Connector	North Main Street (NC 150) to Piney Grove Road (SR 1969)		New 4 lane divided
10	1008	NC 66 to SR 2001 (Winthrop Street) in Guilford County. Widen to Multi-Lanes.	2 lane	5 lane
11	Macey Grove Road Extension (North)	SR 1005 (East Mountain Street) to NC 150 (North Main Street).		New 4 lane divided
13a	Business I-40 (US 421) Interchange at Big Mill Farm Road	Hopkins Road to S. Main Street		New Interchange 4 lane divided
13b	Business I-40 (US 421) Interchange at Big Mill Farm Road	Hopkins Road to NC 66		4 lane divided
14	Macey Grove Road Extension (South)	NC 66 to Industrial Park Drive		New 4 lane divided
16	Linville Springs Road (SR 2030) Extension	Piney Grove Road (SR 1969) to I-73/74 Connector (Regional Aiport Connector)		New 4 lane divided
17	I-73 - I-74 Connector	Northern Beltway/West Mountain Street to Guilford County		New 4 lane freeway
20	US 311 Connector	I-40 to Business I-40		New 4 lane divided
21	Business I-40 (US 421)	Northern Beltway to Guilford County	4 lane freeway	6 lane freeway
23	Kernersville Road (SR 4315)	High Point Road (SR 1003) to Whicker Road	2 lane	3 lane
24	I-40	US 311 to Business 40 Split	4 lane freeway	6 lane freeway
28	Sandy Ridge Road	I-40 to West Market Street	2 lane	4 lane divided
31b	Gallimore Dairy Road	NC 68 to Albert Pick Rd	2 lane	4 lane divided
32	Pegg / Thatcher Connector	W Market Street to Clinard Farms Rd		4 lane divided
33	Sandy Ridge Road Extension	West Market Street to I-40 / NC 68 / I-73 Connector		4 lane divided
35	NC 68	Peeples Road to Rockingham County	2 lane	4 lane divided
36	NC 68	Market Street to Pleasant Ridge Road	4 lane	6 lane divided
37	Burnt Poplar Road	Swing Road to Regional Road	2 lane	3 lane
38	Pleasant Ridge Road	West Market Street to City Limits	2 lane	4 lane divided
39	Pleasant Ridge Road	City Limits to Old Oak Ridge Rd	2 lane	4 lane divided
40	I-73 Connector	NC 68 to Bryan Boulevard		4 lane freeway
41	Pleasant Ridge Road Relocation at I-73 Connector	Montmartre Road to Cude Road		3 lane
42	Bryan Boulevard Loop at I-73 Connector	Montmartre Road to Pleasant Ridge Road		4 lane divided
43	I-73 - I-74 Connector	Forsyth County to NC 68		4 lane divided
44	I-40 Connector	I-40 to I-73 / I-74 Connector		4-6 lane freeway
54	Glenn High Road Extension	Union Cross Road to Teague Lane		4 lane divided
56	Airport Connector	I-73 - I-74 Connector to NC 68		4 lane freeway
58	I-840	Bryan Boulevard to US 220 / US 29		6 lane freeway
59	Thorndike Road	Gallimore Dairy Road to Sandy Ridge Road		2 lane undivided
60	Bunker Hill Sandy Ridge Road	NC 66 to Teague Lane		4 lane divided
67	Winston-Salem North/South Connector	NC 66 to Johnson Street on Squire Davis Road / Sandy Ridge Road	2 lane	4 lane undivided
68	Flemington-Lewiston Connector	Fleming Road to Lewiston Road Connection		4 lane divided
69	Lewiston Road / Pleasant Ridge Road	Urban Loop to NC 150 Relocation	2 lane	4 lane divided

Figure 17. Network Changes Map



4.4 Performance Testing

Model validation is the term used to describe how closely the model's output matches existing travel data in the base year. The 2008 approved model met NCDOT travel demand model validation guidelines, and base year performance was deemed acceptable. However, the NCDOT validation guidelines measure only the model's ability to replicate a static set of conditions (traffic counts). While this provides useful information, its value is limited because the purpose of this study is to forecast how changes in the roadway network would change traffic conditions.

A more valid test of a model's accuracy would focus on the model's ability to predict realistic differences in outputs as inputs are changed; in other words, dynamic validation rather than static validation. In order to review the model's dynamic validation within the PTIA area, the following two tests were performed.

The first test was to see how the model responds to the removal of a link in the road network. For this test, a critical north-south connection was removed, NC 68 between the I-40 on- and off-ramps. Table 4 summarizes the results of this test. The majority of traffic is rerouted to the four parallel connections. As would be expected, there is a small drop in total traffic, since increased congestion and less direct access across I-40 shifts some of the trips to other crossing points along I-40 outside of the testing area.

Table 4. Removal of a Link in the Network

I-40 Overcrossing	With NC 68	Without NC 68	Ratio
Sandy Ridge Road	15,187	20,189	1.33
NC 68 NB	14,565	0	n/a
NC 68 SB	16,497	0	n/a
Gallimore Dairy Road	11,065	22,277	2.01
South Regional Road	7,851	8,808	1.12
Chimney Rock Road	12,890	13,730	1.07
Total	**78,055**	**65,004**	**0.83**

The second test assessed the model response to adding a link to the road network. For this test, the proposed Pegg Road/Thatcher Road extension under I-40 was added. Table 5 summarizes the results of this test. Again, as would be expected, traffic decreases on the five parallel roadways and is rerouted to take advantage of the new capacity on Thatcher Road. In addition, there is a small increase in the total amount of traffic, due to the induced demand of additional roadway facilities.

Table 5. Addition of a Link to the Network

I-40 Overcrossing	Without Thatcher Road Connection	With Thatcher Road Connection	Ratio
Sandy Ridge Road	15,187	12,377	0.81
Thatcher Road	0	6,812	n/a
NC 68 NB	14,565	14,296	0.98
NC 68 SB	16,497	14,890	0.90
Gallimore Dairy Road	11,065	10,195	0.92
South Regional Road	7,851	7,235	0.92
Chimney Rock Road	12,890	12,806	0.99
Total	**78,055**	**78,611**	**1.01**

The results of the dynamic validation tests confirm that the model produces reasonable results for the model application this study requires.

5 Travel Demand Model Forecasting Methodology

This chapter describes the methodology used to develop traffic forecasts for the various projects in the PTIA area. Each step is described in more detail below.

5.1 2035 E+C Model Base Run

A full execution of the Piedmont Triad Regional Travel Demand Model requires approximately twelve hours to complete, while the traffic assignment portion alone requires approximately two hours. Given the number of scenarios that are under evaluation, it would take approximately twelve years to fully execute the model for each scenario. For these reasons, the use of a subarea model representing a smaller geographic portion of the Piedmont Triad Regional Travel Demand Model was selected for this study.

In support of this approach, the 2035 E+C Piedmont Triad Regional Travel Demand Model was run with the land use and roadway network changes described in the previous chapter to develop the baseline origin-destination information for the subarea model. The PM peak hour subarea origin-destination trip tables from the 2035 E+C Piedmont Triad Regional Travel Demand Model were extracted for use in the subarea model.

5.2 Subarea Model Development

To decrease the time required to perform individual scenario runs, the full Piedmont Triad Regional Travel Demand Model was used for the trip generation, trip distribution, and mode choice steps, while the subarea model was used for traffic assignment steps within the project study area. Additionally, the traffic assignment step within the subarea was further streamlined by collapsing the number of vehicle classification bins from 14 (single occupant vehicle, single occupant vehicle toll, high-occupancy vehicle 2, high-occupancy vehicle 2 toll…) to two (personal vehicle and commercial/heavy vehicles). The resulting subarea model required approximately 30 seconds to complete the traffic assignment step within the study area.

5.3 Subarea Model Scenario Runs

A subarea model batch routine was created to execute the traffic assignment step for all of the project scenarios. This took approximately 77 hours to complete using the origin-destination information from the full 2035 E+C Piedmont Triad Regional Travel Demand Model. Twenty-five sets of the resulting traffic forecasts data were reviewed in detail to ensure that the project scenarios were correctly coded and that the resulting traffic forecasts were reasonable.

6 Subarea Model Results

6.1 Traffic Statistics

The travel demand forecasting for this project was accomplished using a combination of the most recent Piedmont Triad Regional Travel Demand Model (with land use and roadway network modifications as previously described) and a subarea travel demand model representing a portion of the model within the PTIA area.

It is important to recognize that regional models such as the Piedmont Triad Regional Travel Demand Model typically represent only major components of the roadway network and are calibrated/validated to the level of screenlines and major corridor volumes. These models are best-suited to forecast regional-level traffic patterns, and usually lack sufficient detail to provide reasonable forecasts at the intersection turning movement level.

As a result, specific traffic volumes were not used as performance measures; rather the following aggregate statistics were calculated over the entire subarea for each scenario:

- Vehicle miles traveled (VMT)
- Vehicle hours traveled (VHT)
- Vehicle hours of delay (VHD)

While each measure is a standard aggregate reporting statistic for travel demand model work and is helpful for comparing scenarios against each other, VHD was selected as the most meaningful statistic for this study because it directly measures traffic congestion. Specifically, it indicates the additional time spent on the network due to other traffic.

VHD is inversely related to user benefit; a reduction in VHD results in reduced travel time and decreased idle time, which saves money and lessens pollutants. Alternatively, VMT and VHT are not directly related to user benefit; while an increase in VMT or VHT does lead to increased travel and mobility, the additional travel also results in increased air pollution and promotes non-dense development patterns. Furthermore, changes in VMT and VHT are more beneficial to longer trips, which are typically regional in nature (especially along I-40 through the study area).

6.2 Evaluation Criteria

As noted in the first chapter, the purpose of this study is to evaluate the various proposed roadway projects and alternatives in the PTIA area. The evaluation of these projects will improve GUAMPO's decision-making by providing objective and comparative measures of project performance. This performance includes traffic statistics along with cost information, provided earlier in the report. The following section provides benefit/cost analysis information that provides insight into the return on investment for the different projects. Ultimately, this information is most useful for designing a project implementation plan intended to meet specific GUAMPO objectives.

6.3 Project Scenario Analysis

The model data and cost information were combined to create the following variables:

- Projects – Number of individual projects included in each scenario, ranging from one to twelve.
- Cost (Million) – Total cost of the projects included in each scenario, in millions of dollars.
- VHD Reduction – Difference in VHD between each scenario and the base scenario (2035 E+C network, no scenario projects).
- VHD Reduction/Project – Total VHD reduction per number of projects included in each scenario.
- VHD Reduction/Cost (Million) – Total VHD reduction per scenario cost.

Due to the large number of scenarios under evaluation, the initial screening of scenario performance involved the creation of Figures 18 through 22, which compare the scenario variables by highlighting different relationships.

Figure 18 compares the scenario cost with its corresponding VHD reduction. As shown on the figure, almost all scenarios result in a VHD reduction from the base case (2035 E+C: 15,047 VHD), with a maximum reduction of approximately 6,100 VHD.

Figure 18. Cost (Million) vs. VHD Reduction

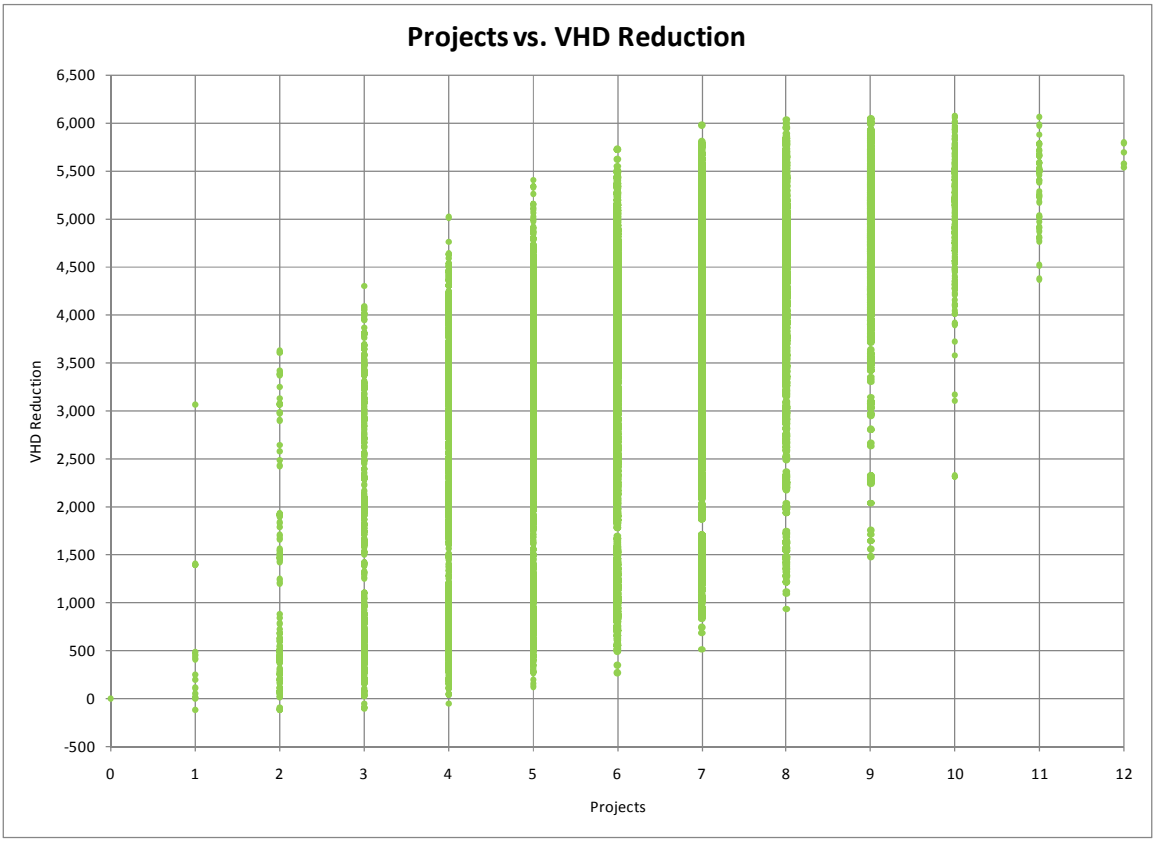
actually increase VHD (These scenarios include projects that may eliminate a bottleneck in one area, only to move it to another, more constrained location). The most interesting finding from this figure is the tradeoff between cost and VHD reduction.

While the general trend indicates increasing cost yields a higher VHD, there is a wide range of performance at each cost increment. For example, spending approximately $600 million can generate a VHD reduction ranging from approximately 2,200 to 5,000, depending on which specific projects are built. This result indicates that the combination of projects (especially complimentary projects such as the I-73 Connector and the Airport Connector) has more influence on VHD reduction than does the total cost of the scenario.

Figure 18 also begins to reveal the issue of diminishing returns -- a topic covered in more detail in the discussion of Figure 21. For example, doubling the infrastructure investment by adding a second $600 million in projects yields only 20% of the delay reduction obtained from the first $600 million investment (assuming that $600 million was optimally spent).

Figure 19 organizes results by comparing the number of projects in a scenario to the VHD reduction. The general trend indicates that the more projects a scenario has, the larger the VHD reduction. That being said, the specific combination of projects can result in drastically different VHD reduction levels. For example, scenarios with seven projects can result in VHD reductions between approximately 500 and 6,000. These results further confirm that the specific combination of projects is the most important predictor of VHD reduction, even more important than the number of projects.

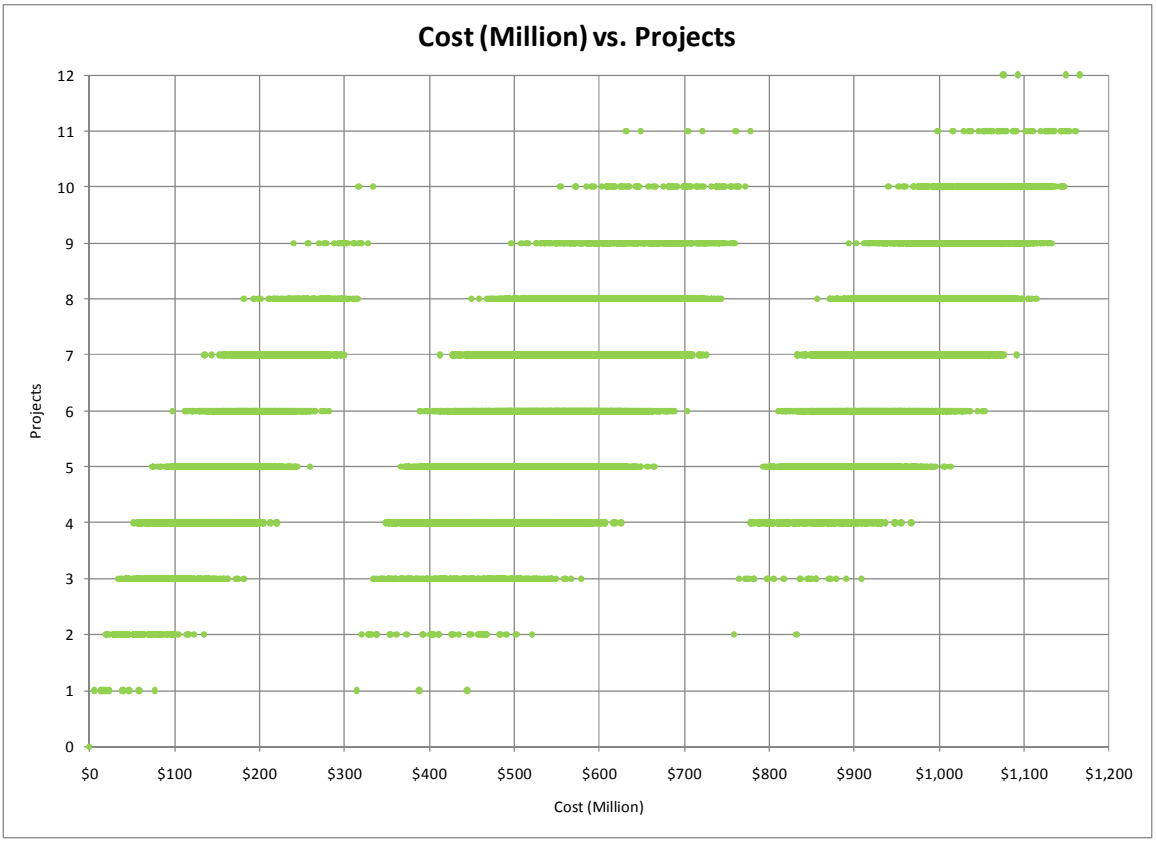
Figure 19. Projects vs. VHD Reduction



It should also be noted that the scenario yielding the highest VHD reduction (approximately 6,100) includes only ten projects. Adding an eleventh or twelfth project results in a lower VHD reduction, indicating that, while they may provide additional roadway capacity or routing options, some of these projects are redundant, especially when constructed with a host of other projects.

Figure 20 compares the cost of each scenario to the number of projects constructed. There is no clear relationship between the cost of a scenario and the number of projects. It may be expected that the number of projects in a scenario should increase with the total cost. This is not the case in the PTIA area due to huge cost differences between individual projects, specifically freeway projects versus local roadway projects. For example, spending approximately $440 million allows for a scenario that constructs only the I-40 widening project, while spending approximately $250 million allows for a scenario that constructs nine separate, smaller projects.

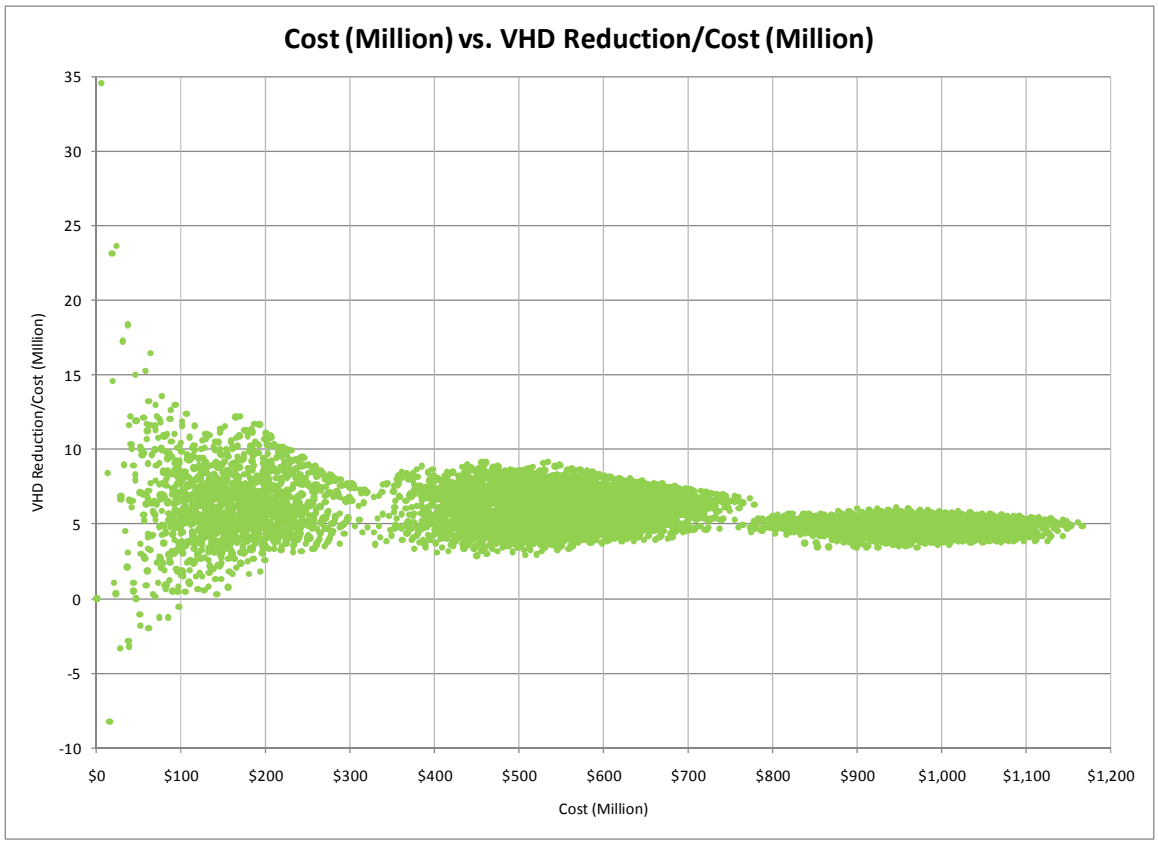
Figure 20. Cost (Million) vs. Projects



This provides additional proof that the specific combination of projects is important to scenario performance, particularly the resulting cost. A similar amount can be spent on different scenarios that construct one large project or multiple smaller projects. While the large project may yield the greatest reduction in VHD, the multiple smaller projects may still result in a substantial reduction in VHD while also addressing a host of secondary needs (local access, increased goods movement, etc).

Figure 21 compares scenario cost to VHD reduction/cost, which is essentially a measure of per dollar effectiveness (in terms of VHD reduction), for each additional dollar spent on a scenario. The general trend shows that the additional effectiveness of any dollar spent on a scenario converges around 5.0, as the total scenario cost increases. The real variation in VHD reduction/cost occurs between $0 and $300 million, which indicates some of the cheaper scenarios provide a greater VHD reduction/cost than more expensive scenarios. These scenarios primarily contain roadway widening projects, which are much less expensive than new freeway construction.

Figure 21. Cost (Million) vs. VHD Reduction/Cost (Million)

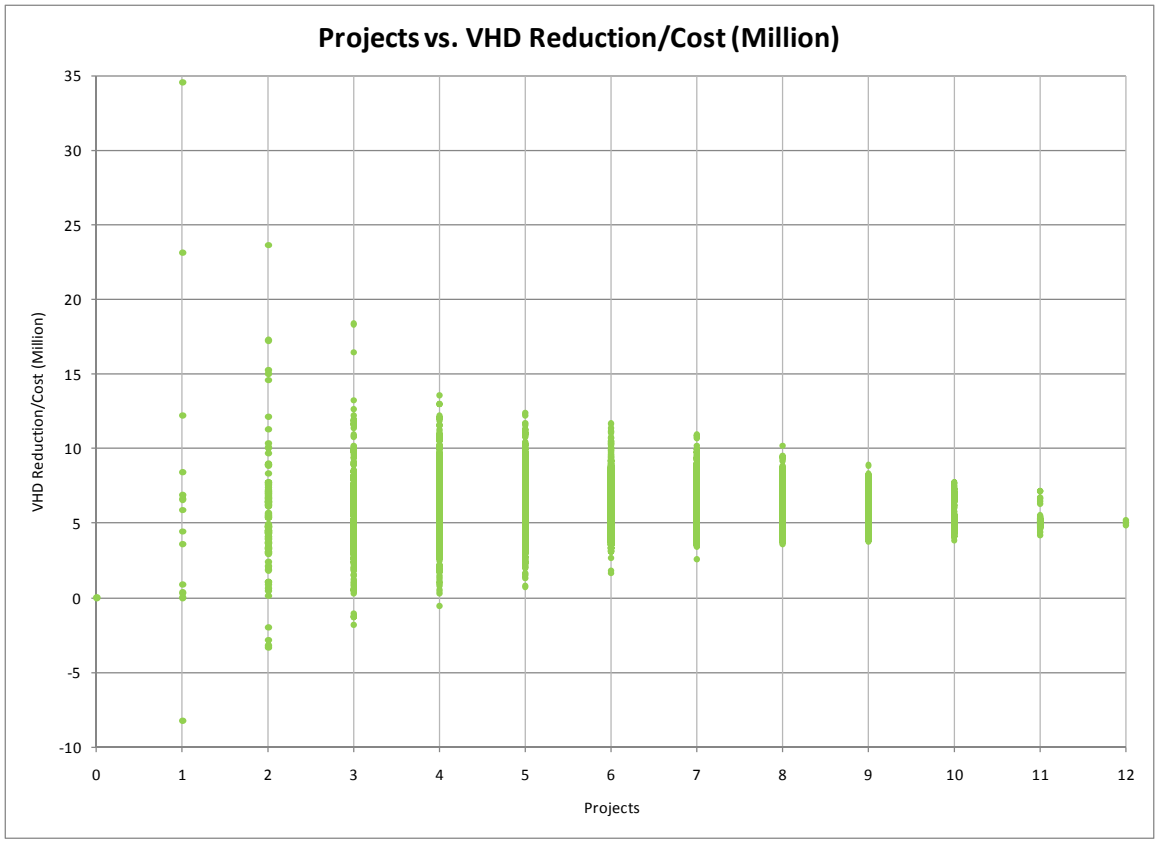


The general pattern in the figure shows that there are diminishing returns for each additional dollar spent on a given project scenario. Alternatively, there is greater VHD reduction/cost associated with the cheaper projects. This is important to acknowledge, due to the inherent risk associated with future activities, such as constructing roadway projects. In light of this, the future must be discounted because there is risk that some or all of the projects in a given scenario might not be built. History shows that money or other factors may limit the ultimate completion of all the projects.

Figure 22 compares the number of projects constructed to the corresponding VHD reduction/cost. The trend is similar to that of the previous figure, though this reveals that the top performing scenarios tend to have four or fewer projects. Additionally, the rate of return appears to flatten between seven and ten projects, and then decline further with eleven or twelve projects. Similar to the previous comments, the combination of projects

matters to the performance of a scenario. In this case, scenarios that contain more than seven projects do not provide additional VHD reduction in proportion to their additional cost.

Figure 22. Projects vs. VHD Reduction/Cost (Million)



6.4 Implementation Plan Strategies

As noted above, scenario performance is directly related to specific project combinations. While there is no prescribed method for determining the best sequence for building the projects under evaluation, there are three distinct implementation plan strategies for the PTIA area:

- Minimize cost
- Maximize VHD reduction
- Maximize VHD reduction/cost

Each strategy is viable and provides a valid basis for decision-making, though the timing and magnitude of VHD reduction and costs differ.

6.5 Minimize Cost Strategy

As shown in Table 6, this implementation plan focuses on building projects in order of increasing cost. This strategy calls for the construction of local road projects before any new freeway projects are built. This strategy is favorable from a financial standpoint, because it allows for the construction of six projects while spending less than $100 million. However, this strategy does not produce a 1,000 VHD reduction (roughly 18% of the maximum) until the seventh project.

Table 6. Minimize Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pleasant Ridge Road Widening	275	$ 18.8	14.6
3	Pleasant Ridge Road Relocation	153	$ 33.7	4.5
4	Pegg/Thatcher Street Connection	518	$ 51.6	10.0
5	Sandy Ridge Road Extension (North)	569	$ 74.3	7.7
6	Airport Connector	758	$ 97.4	7.8
7	Bryan Boulevard Loop	1,015	$ 135.2	7.5
8	I-40 Connector	1,472	$ 181.6	8.1
9	NC 68 Widening	1,559	$ 239.7	6.5
10	I-73 Connector	2,319	$ 316.5	7.3
11	I-73/I-74 Connector (Arterial)	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

6.6 Maximize VHD Reduction Strategy

As shown in Table 7, this implementation plan focuses on building projects in order of increasing VHD reduction. This strategy calls for the construction of new freeway projects before constructing any local road projects. This strategy is favorable from a traffic standpoint, because it produces a 3,059 VHD reduction (roughly 51% of the maximum) with the first project. However, this strategy frontloads the costs and surpasses $1,000 million with the construction of the seventh project. It should be noted that the "maximize VHD reduction" strategy project sequence is almost a mirror image of the "minimize cost" strategy.

Table 7. Maximize VHD Reduction Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	I-40 Widening	3,059	$ 444.1	6.9
2	I-73/I-74 Connector (Freeway)	3,602	$ 832.1	4.3
3	Airport Connector	4,296	$ 855.2	5.0
4	I-73 Connector	5,016	$ 932.1	5.4
5	I-40 Connector	5,406	$ 978.4	5.5
6	Pegg/Thatcher Street Connection	5,725	$ 996.3	5.7
7	Sandy Ridge Road Extension (North)	5,977	$ 1,019.0	5.9
8	Bryan Boulevard Loop	6,031	$ 1,056.8	5.7
9	NC 68 Widening	6,050	$ 1,114.9	5.4
10	Pleasant Ridge Road Relocation	6,078	$ 1,129.8	5.4
11	Pleasant Ridge Road Widening	6,060	$ 1,143.0	5.3
12	Sandy Ridge Road Widening	5,790	$ 1,148.6	5.0

6.7 Maximize VHD Reduction/Cost Strategy

As shown in Table 8, this implementation plan focuses on building projects in order of greatest incremental VHD reduction/cost, or the most effective projects per dollar spent. This strategy calls for the construction of local roadways before new freeway projects. This strategy is favorable from a VHD reduction/cost standpoint, because it produces a 1,250 VHD reduction (roughly 22% of the maximum) with the construction of the fifth project, for a cost of only $151.2 million. This strategy backloads the costs and requires an increment of $444.1 million between the tenth and eleventh projects. It should be noted that the "maximize VHD reduction/cost" strategy project sequence is very similar to the "minimize cost" strategy.

Table 8. Maximize VHD Reduction/Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pegg/Thatcher Street Connection	553	$ 23.4	23.6
3	Pleasant Ridge Road Widening	673	$ 36.7	18.3
4	Bryan Boulevard Loop	899	$ 74.4	12.1
5	I-73 Connector	1,250	$ 151.2	8.3
6	Pleasant Ridge Road Relocation	1,328	$ 166.1	8.0
7	Airport Connector	1,328	$ 189.2	7.0
8	I-40 Connector	2,209	$ 235.6	9.4
9	Sandy Ridge Road Extension (North)	2,299	$ 258.4	8.9
10	I-73/I-74 Connector (Arterial)	4,440	$ 573.2	7.7
11	NC 68 Widening	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

6.8 Comparison of Strategies

Figures 23 through 27 provide visual representations of the performance of the three implementation plan strategies. All three strategies perform well, especially when compared to the entire set of project combinations evaluated. While no single strategy clearly stands out as preferred, the "maximize VHD reduction/cost" strategy blends both the "minimize cost" and "maximize VHD reduction" strategies together.

Ultimately, this balance of VHD reduction and cost performance is a very reasonable strategy, and if pursued would be defendable from a cost standpoint, while also resulting in traffic improvements in the PTIA area. Additionally, the "maximize VHD reduction/cost" strategy is best for minimizing future risk. While all three strategies have similar VHD reduction at the end of the implementation plan (if all twelve projects are constructed and is considered a complete system), the "maximize VHD reduction/cost" strategy is a conservative approach that incrementally builds the best returning project out of all remaining available projects.

Since funding or other factors may halt ultimate completion of any implementation plan, the "maximize VHD reduction/cost" strategy provides interim systems that work – projects constructed in the early stages of the implementation plan are not dependent on the construction of other, future projects to realize the full value of earlier constructed projects. Therefore, a reasonable strategy is one that constructs a system that works well during all interim stages, since the ultimate completion of the implementation plan is an unknown variable that could be delayed, altered, or never fully realized.

Figure 23. Cost (Million) vs. VHD Reduction

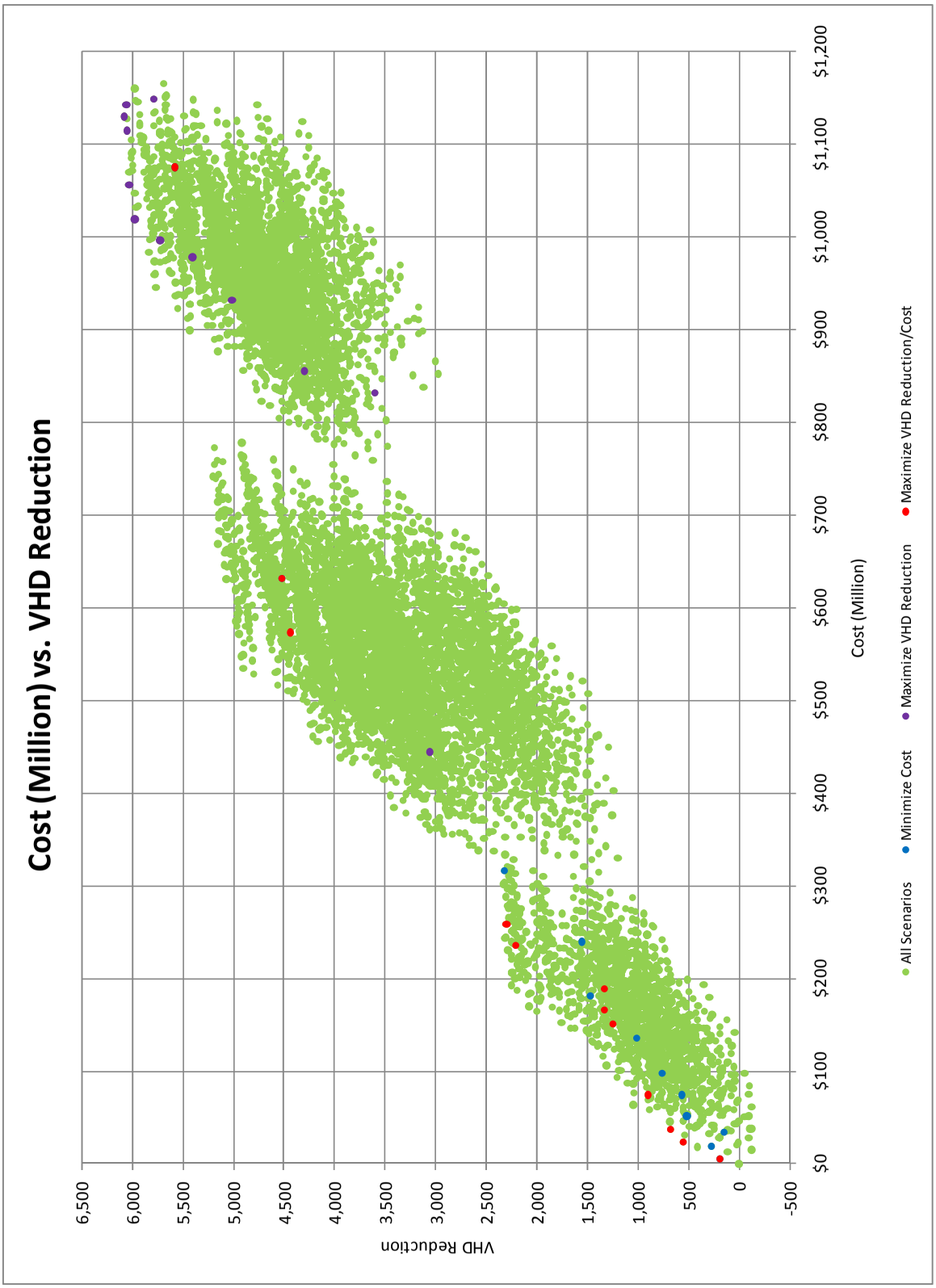


Figure 24. Projects vs. VHD Reduction

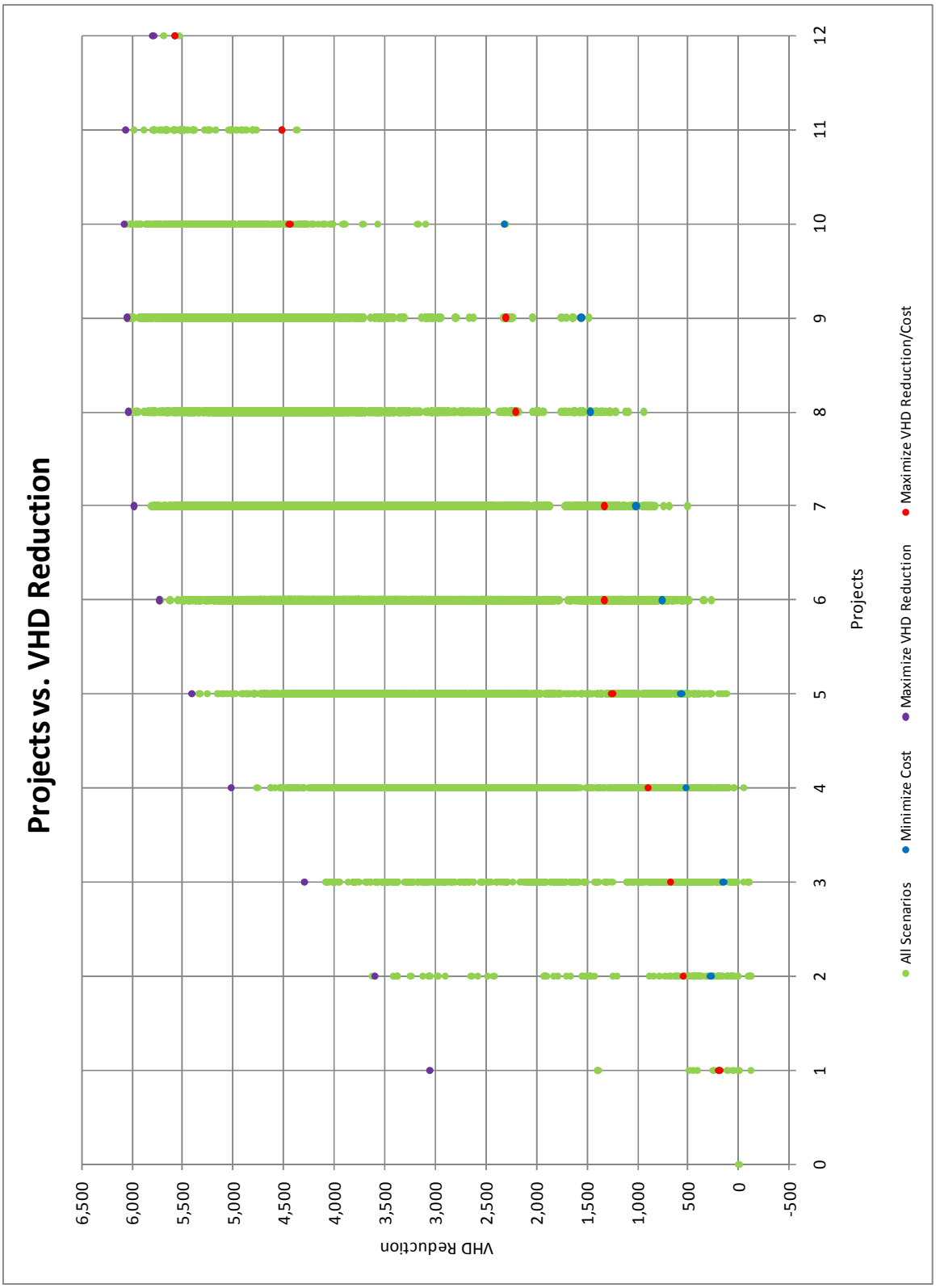


Figure 25. Cost (Million) vs. Projects

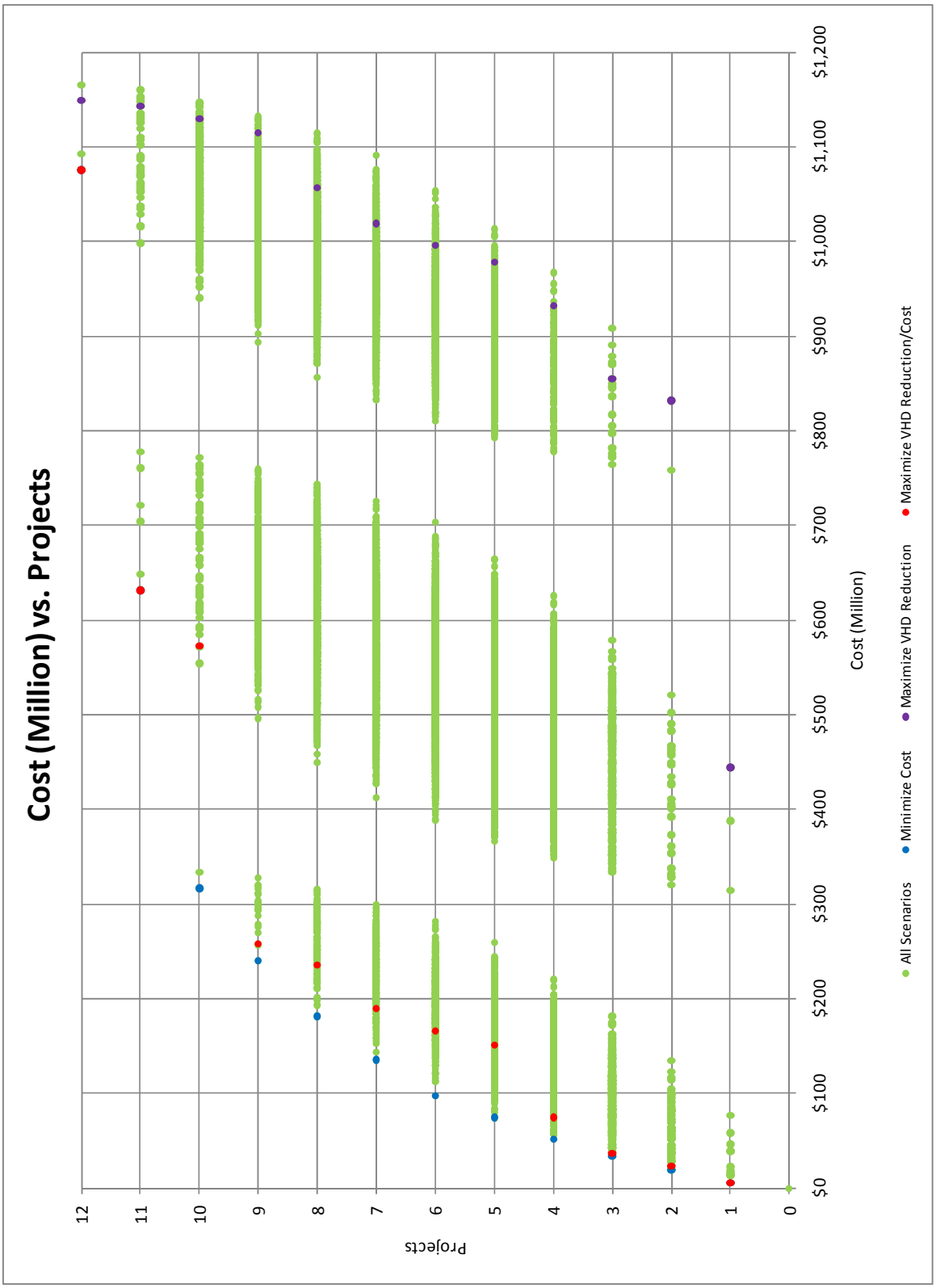


Figure 26. Cost (Million) vs. VHD Reduction/Cost (Million)

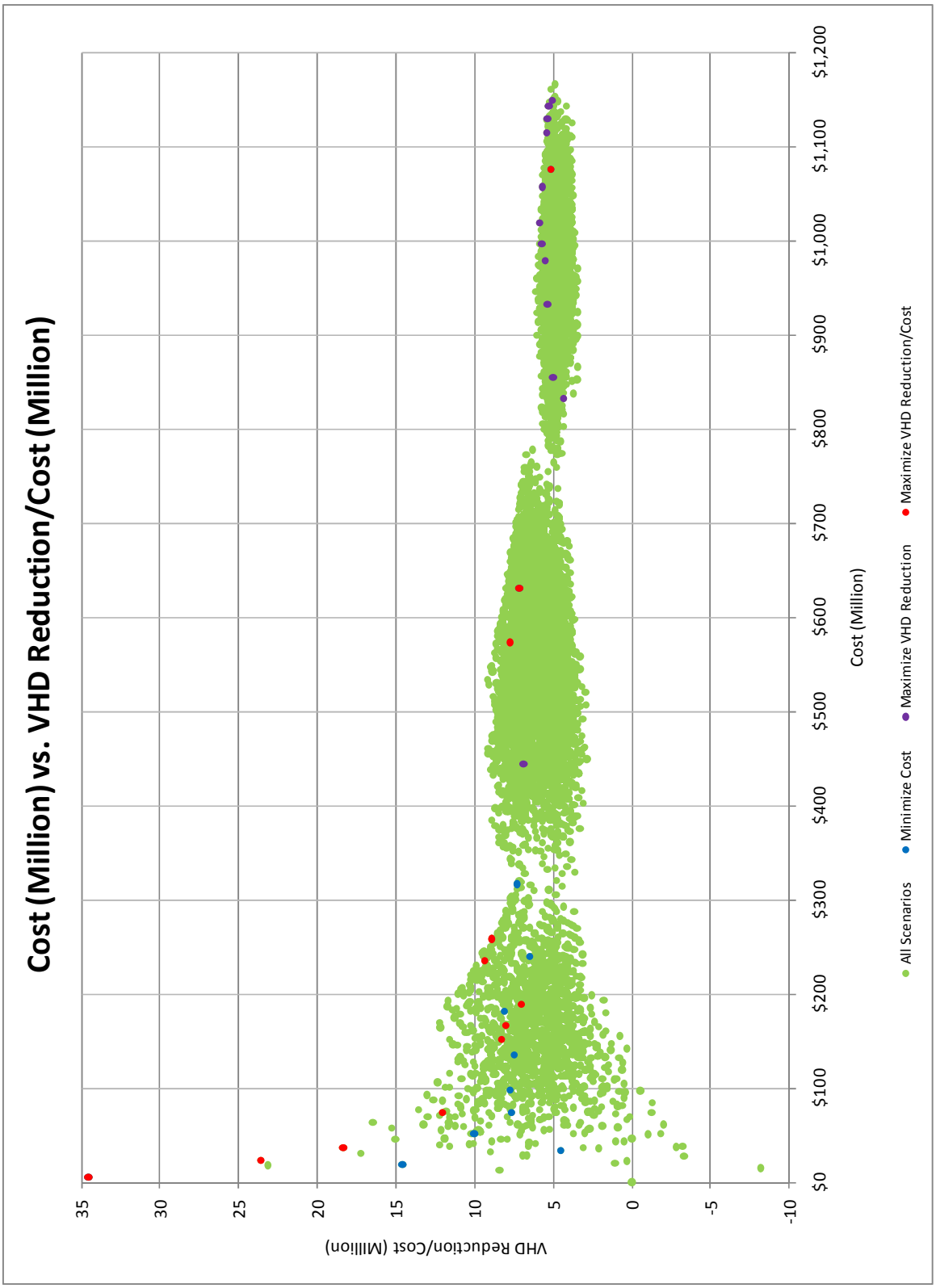
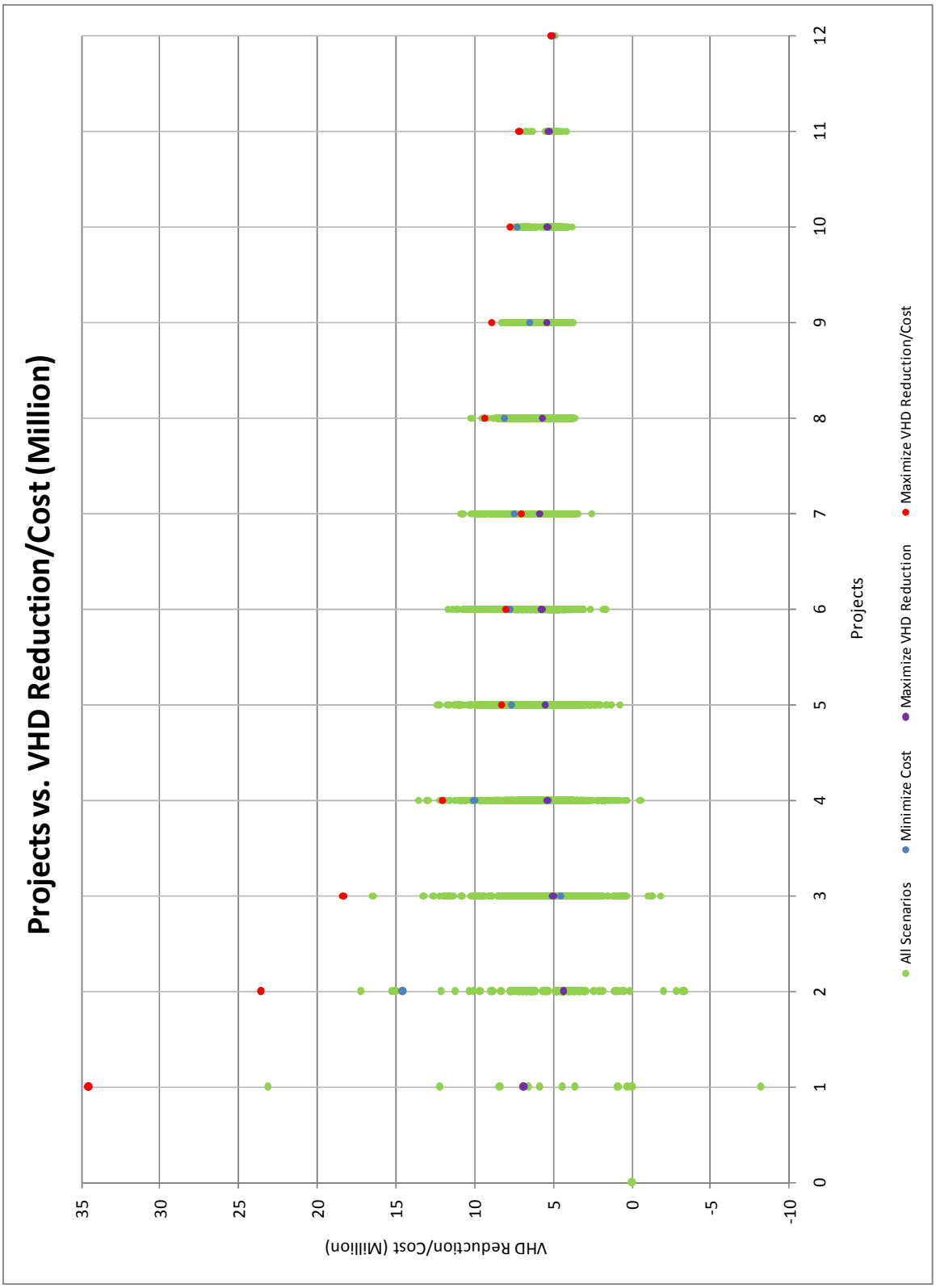


Figure 27. Projects vs. VHD Reduction/Cost (Million)



6.9 Notable Results

During the evaluation of the project scenarios and the implementation plan strategies, the following notable results became clear:

Sandy Ridge Road Widening

- Enhances Market Street widening project.
- Increases capacity parallel to I-40 by improving connectivity and access to alternate routes.
- Provides alternative access to the airport from the west and south.

Pegg/Thatcher Street Connection

- Driven primarily by land use development.
- Does not provide very equitable north-south capacity enhancements.

Sandy Ridge Road Extension

- East extension is not viable once I-73 Connector is built, due to loss of access to PTIA via Bryan Boulevard.
- North extension is viable only after the Airport Connector is built.
- A development driven collector extension could be beneficial, though no specific alternative was evaluated during the study.

NC 68 Widening

- Enhances Market Street widening project.
- Increases capacity parallel to I-73.
- Provides alternative access to the airport from the north, west, and south.

Pleasant Ridge Road Widening

- Enhances Market Street widening project.

- Reduces the need for a Sandy Ridge Road extension by providing a similar function when combined with widenings of Sandy Ridge Road and West Market Street.
- Provides alternative access to the airport from the west and south.
- Improves local access.

I-73 Connector

- Duplicates existing roadways that perform well today.
- Provides justification for Airport Connector.

Pleasant Ridge Relocation

- Warranted only after I-73 Connector and Airport Connector are built.
- Enhances local access.

I-73/74 Connector

- Arterial and Freeway options provide similar traffic benefits.
- Justified only after construction of the Airport Connector and/or Sandy Ridge Road Extension (North) and/or I-40 Connector.
- Will require additional improvements to local facilities serving the project.

I-40 Connector

- Traffic volumes and resulting benefits from this project are closely interrelated with other project decisions. The most significant interactions are associated with the widening of I-40, since these two projects share a substantial travel market. Combined with the Airport Connector and several road widening projects, the I-40 Connector could shift enough traffic off of I-40 to reduce or eliminate widen the segment between NC 68 and I-40 Bus. Conversely, if I-40 were to be widened, volumes on the I-40 Connector would be lower.

Airport Connector

- Arterial and Freeway options provide similar traffic benefits.

- Not justified until I-73/I-74 Connector, I-73 Connector, or I-40 Connector (or some combination) is built.

I-73 Connector Loop Roads

- Important for local access.
- Not justified until I-73 Connector and Airport Connector are built.

I-40 Widening

- Greatest benefit and greatest cost (as an individual project). However, some benefits in the study area (especially along I-40 between I-40 Bus and NC 68) can be obtained from other projects that shift traffic off of I-40. For example, building the I-40 Connector and the Airport Connector (combined with some other road widening) substantially lowers traffic on this portion of I-40, and could delay or eliminate the need for widening. On the other hand, completing the widening of I-40 could reduce the utility or demand for some of these (or other) projects.
- Difficult to construct while maintaining existing traffic patterns.

6.10 Other Considerations

The focus of this study involved the benchmarking and evaluation of project scenarios using traffic and cost information. While these two components are important factors influencing the selection and construction of roadway projects, they are by no means the only factors decision makers should consider. The following factors should be considered in concert with the results of this study:

- Local accessibility
- Changes in regional traffic patterns
- Goods movement
- Roadway network impact on development patterns
- Travel time changes to PTIA
- Enhancements to alternative modes

Greensboro Airport Area Modeling Study

December 2009

Prepared for the

Greensboro Urban Area

Metropolitan Planning Organization

MARTIN
ALEXIOU
BRYSON

Inside Front Cover

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Table of Contents

1 Executive Summary

1.1 Purpose

The purpose of the analysis is to revaluate the projects in the Piedmont Triad International Airport (PTIA) area. There are currently multiple combinations of twelve separate projects that could be constructed in the PTIA area. The technical evaluation of cumulative conditions in the PTIA area will support Greensboro Urban Area Metropolitan Planning Organization (GUAMPO) transportation system planning decisions. It will ensure that all previously identified project needs still exist and that the various proposed roadways in the area will meet these needs.

1.2 Project Scenario Analysis

The projects under consideration in the PTIA area were evaluated with the following travel demand model data and cost information:

- Projects – Number of individual projects included in each scenario, ranging from one to twelve.
- Cost (Million) – Total cost of the projects included in each scenario, in millions of dollars.
- VHD (Vehicle Hours of Delay) Reduction – Difference in VHD between each scenario and the base scenario (2035 E+C network, no scenario projects).
- VHD Reduction/Project – Total VHD reduction per number of projects included in each scenario.
- VHD Reduction/Cost (Million) – Total VHD reduction per scenario cost.

The above data was used to develop three implementation plan strategies for constructing the twelve projects.

1.3 Preferred Implementation Plan Strategy

As shown in Table 8, this implementation plan focuses on building projects in order of greatest incremental VHD reduction/cost, or the most effective projects per dollar spent. This strategy calls for the construction of local roadways before new freeway projects. This strategy is favorable from a VHD reduction/cost standpoint, because it produces a 1,250 VHD reduction (roughly 22% of the maximum) with the construction of the fifth project, for a cost of only $151.2 million. This strategy backloads the costs and requires an increment of $444.1 million between the tenth and eleventh projects. It should be noted that the "maximize VHD reduction/cost" strategy project sequence is very similar to the "minimize cost" strategy.

Table 1. Maximize VHD Reduction/Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pegg/Thatcher Street Connection	553	$ 23.4	23.6
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11	NC 68 Widening	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

1.4 Comparison of Strategies

Ultimately, the balance of VHD reduction and cost performance is a very reasonable strategy, and if pursued would be defendable from a cost standpoint, while also resulting in traffic improvements in the PTIA area. Additionally, the "maximize VHD reduction/cost" strategy is best for minimizing future risk. While all three strategies have similar VHD reduction at the end of the implementation plan (if all twelve projects are constructed and is considered a complete system), the "maximize VHD reduction/cost" strategy is a conservative approach that incrementally builds the best returning project out of all remaining available projects.

Since funding or other factors may halt ultimate completion of any implementation plan, the "maximize VHD reduction/cost" strategy provides interim systems that work – projects constructed in the early stages of the implementation plan are not dependent on the later construction of other projects to realize the full value of earlier constructed projects. Therefore, a reasonable strategy is one that provides a desirable outcome at each interim stages of implementation, since the completion of the ultimate plan as currently envisioned cannot be guaranteed, due to unforeseeable changes in funding, growth and development, construction schedules, programming priorities, and other conditions.

2 Introduction

The Greensboro Urban Area Thoroughfare Plan (GUATP) includes important conceptual roadways near Piedmont Triad International Airport (PTIA). Many of the roadways were recommended as a part of the 2004 Triad International Airport Area Transportation Study. Major roadways resulting from the study include: Airport Connector (I-73/ I-74 Connector), I-40 Connector, and the Sandy Ridge Extension. Both connectors are identified as freeways, while Sandy Ridge Extension is a major thoroughfare.

Since the release of the GUATP by the Greensboro Urban Area Metropolitan Planning Organization (GUAMPO), additional planning studies have been conducted, including the Heart of the Triad Plan and the 2035 GUAMPO Long Range Transportation Plan (LRTP). Additionally, land in and around PTIA has been identified for airport and private development. Finally, the economic landscape has greatly changed within the last year and there is a greater emphasis on cost performance of major infrastructure investment projects. As such, GUAMPO decided to revaluate the planned roadway network near PTIA to ensure that the proposed roadways are needed and cost-effective.

It should be noted that PTIA is currently conducting a study of the Airport Area including the evaluation of roadways serving the airport. However, recommendations from the PTIA study were not available before the completion of this report.

2.1 Background

The Airport Area Transportation Study was completed by NCDOT in cooperation with the Triad MPOs and Piedmont Authority for Regional Transportation (PART). The recommended roadways noted above where added to the Greensboro Urban Area Thoroughfare Plan. The study also recommended the deletion of proposed projects shown on the Greensboro Thoroughfare Plan; they included the Sandy Ridge Road Connector from Sandy Ridge Road to Pleasant Ridge Road. This project was recommended for deletion as it was determined that the connection would result in an unacceptable LOS on Pleasant Ridge Road.

The study also recommended the deletion of the Joseph M. Bryan Boulevard Extension from NC 68 to Pleasant Ridge Road. It was recommended for deletion because it was believed the cost outweighed the benefit. However, the MPO decided to retain the proposed extension of Joseph M. Bryan Boulevard to Pleasant Ridge Road.

2.2 Purpose

The purpose of the analysis is to revaluate the projects in the PTIA area, including I-73/I-74 Connector, I-40 Connector, and Sandy Ridge Road Extension. There are currently multiple combinations of twelve separate projects that could be constructed in the PTIA area. The technical evaluation of cumulative conditions in the PTIA area will support GUAMPO transportation system planning decisions and ensure that all previously identified project needs still exist and that the various proposed roadways in the area will meet these needs. Additionally, the modeling work completed for this project will be used in support of the Sandy Ridge Road Widening and Extension Feasibility Study, currently underway.

2.3 Study Area

The PTIA is located in Guilford County, close to the Forsyth County border, and is bounded by Joseph M. Bryan Boulevard to the north, W. Market Street to the south, I-73 to the east, and NC 68 to the west. PTIA is located approximately 9 miles from downtown Greensboro, 11 miles from downtown High Point, and 16 miles from downtown Winston-Salem.

The study area for this project includes portions of the Piedmont Triad Region, which encompasses the Greensboro, Winston-Salem/Forsyth, High Point, and Burlington-Graham MPOs. The Piedmont Triad Regional Travel Demand Model (PTR TDM) covers all of the MPO boundaries, though only a subarea of the total model, described as the PTIA area within this report, was utilized for detailed traffic analysis.

This study area was selected for purposes of traffic forecasting because the projects in the PTIA area have the potential to draw traffic from the local surface streets, which are often congested during the peak periods. The project study area covers a larger extent than the actual roadway improvement design limits because it is necessary to examine the regional effects of traffic diversion through the area. Figures 1 and 2 show the extents of the PTR TDM and the PTIA area (shown in black), respectively.

Figure 1. Piedmont Triad Regional Travel Demand Model Extents

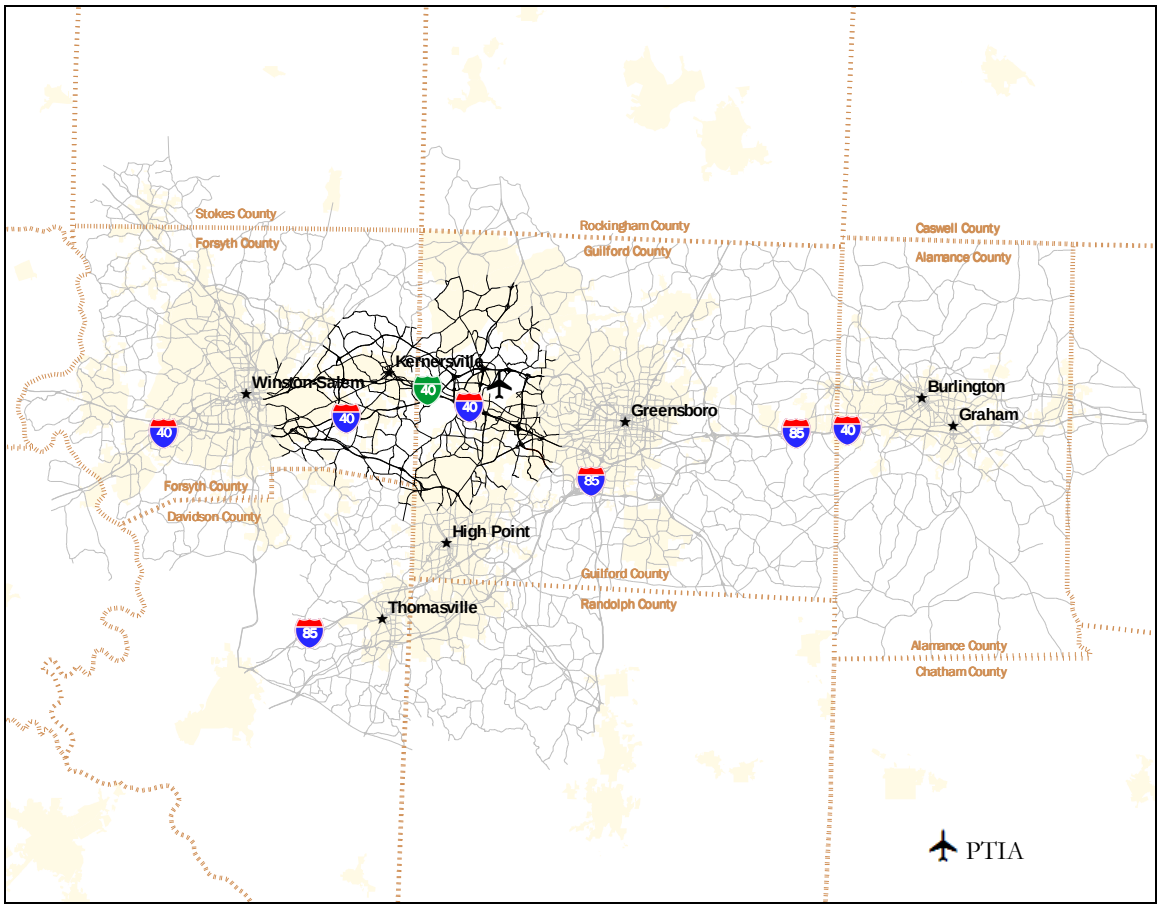
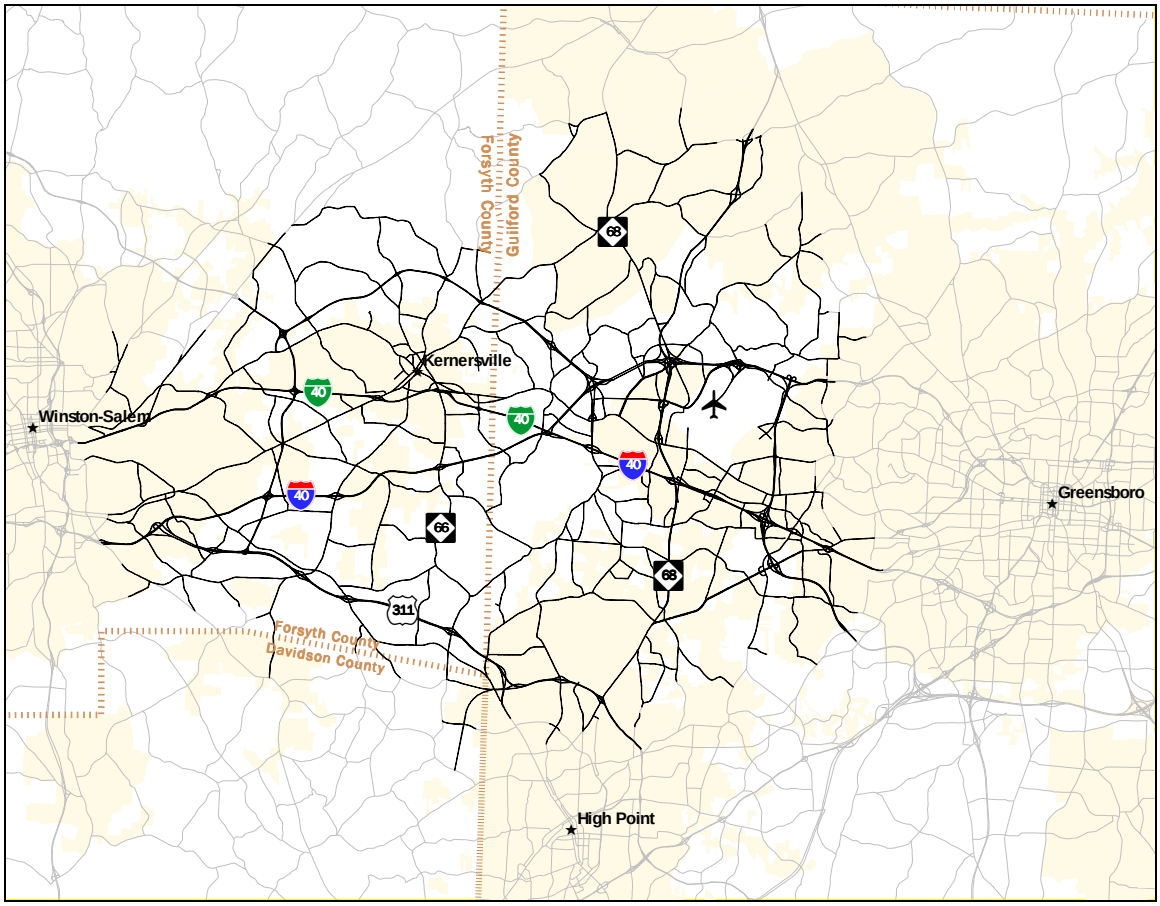


Figure 2. Piedmont Triad Airport Subarea Model Extents



2.4 Study Oversight

GUAMPO staff guided this study, though the following stakeholder group was consulted throughout the project:

- City of Greensboro Planning and Engineering
- City of High Point DOT
- City of Winston-Salem Planning and Engineering
- Town of Kernersville Public Works Department
- Piedmont Triad International Airport Authority
- Greensboro Metropolitan Planning Organization
- Winston-Salem Forsyth Metropolitan Planning Organization
- High Point Metropolitan Planning Organization
- Piedmont Authority for Regional Transportation
- North Carolina Department of Transportation

3 Projects Under Evaluation

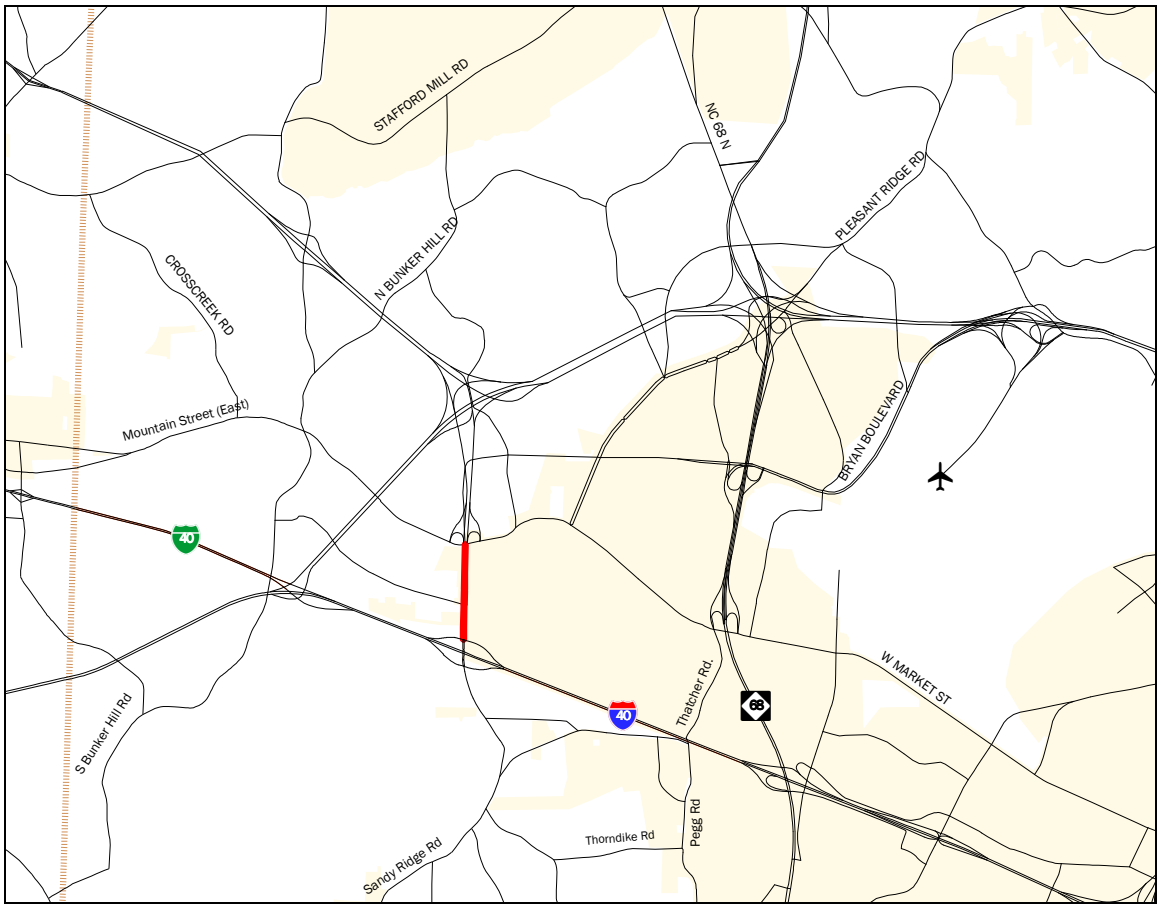
For this study, twelve projects are under consideration, some with multiple alternatives, as detailed in the following sections. Each project is designated by a letter (A-G) and a number (if there are multiple design options). Cost estimates (right of way and construction) for each project and design option are taken from the GUAMPO and WSMPO 2035 LRTPs, NCDOT feasibility studies, and NCDOT cost estimation sheets.

3.1 Sandy Ridge Road Widening

This project involves widening Sandy Ridge Road between I-40 and West Market Street. The existing Sandy Ridge Road is a collector road with one lane in each direction and no median. The proposed project widens this segment to two lanes in each direction with a median. The location of the Sandy Ridge Road widening project is shown in red on Figure 3.

- Project A1 – Existing Sandy Ridge Road – $0
- Project A2 – Widened Sandy Ridge Road – $5,554,852

Figure 3. Sandy Ridge Road Widening Project Extents

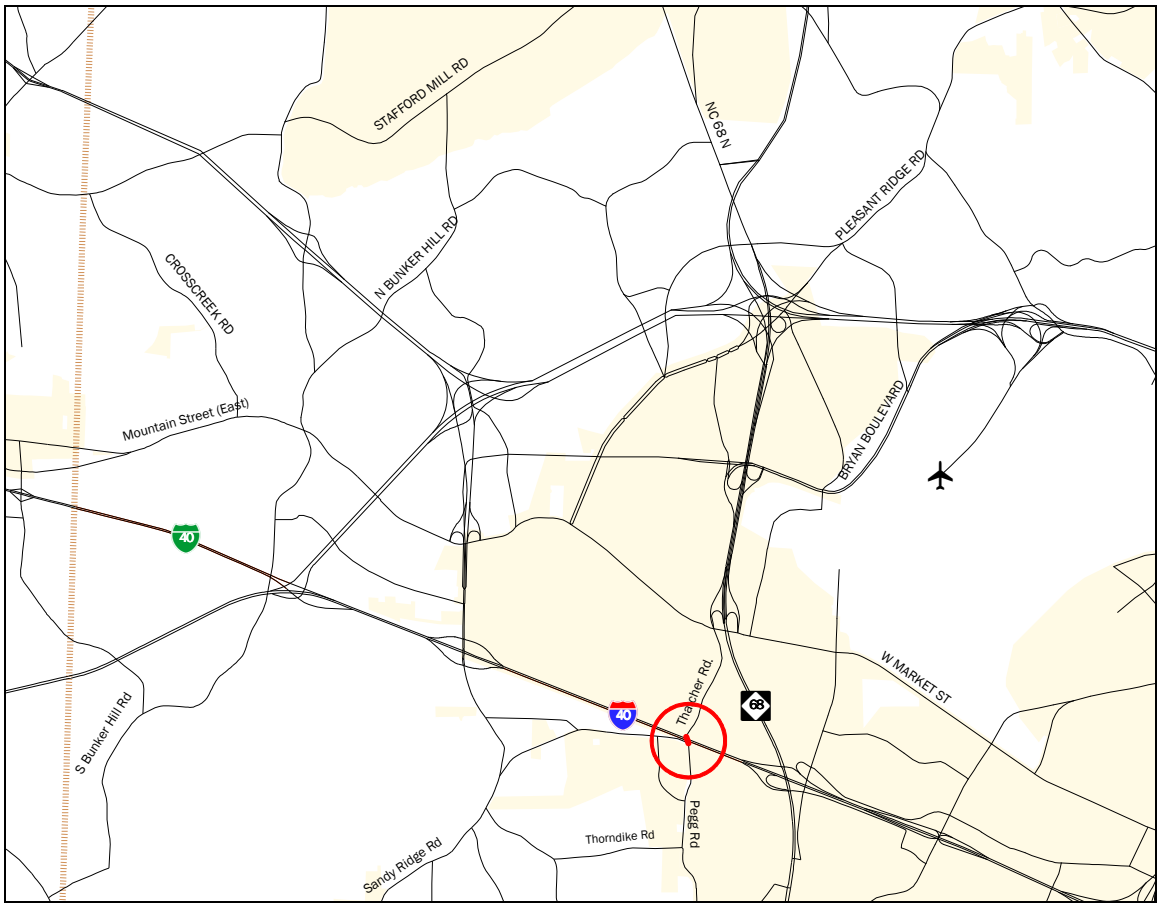


3.2 Pegg Road/Thatcher Road Connector

This project involves construction of a new facility to connect Pegg Road and Thatcher Road, which are currently separated by I-40. The proposed project adds a collector street with two lanes in each direction and a median that provides connectivity via a bridge over I-40. The location of the Pegg Road/Thatcher Road Connector project is shown in red on Figure 4.

- Project B – Pegg Road/Thatcher Road Connector – $17,855,910

Figure 4. Pegg Road/Thatcher Road Connector Project Extents

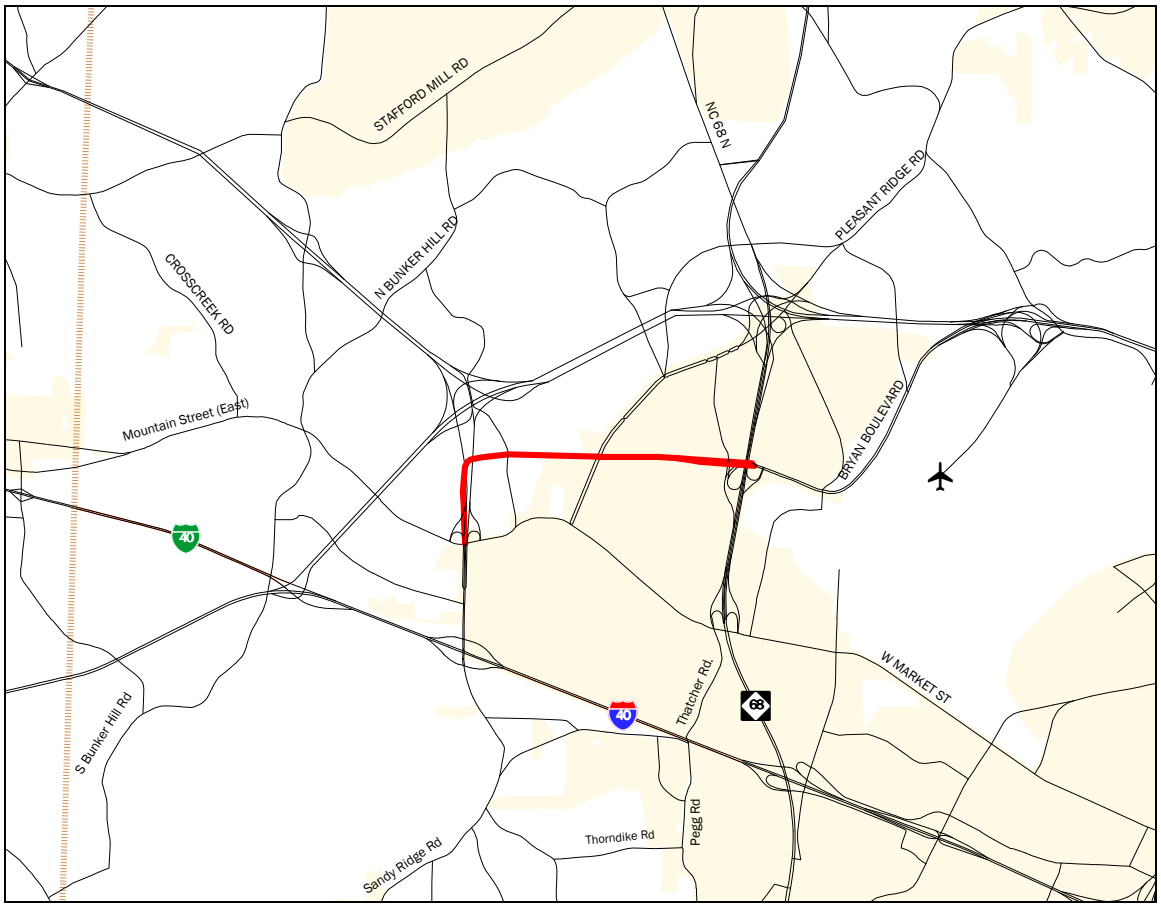


3.3 Sandy Ridge Road Extension

This project involves construction of a new facility to extend Sandy Ridge Road to either: 1) Bryan Boulevard (Eastern Extension) or 2) the proposed I-40 Connector (Northern Extension). The proposed Eastern Extension project is an arterial street with two lanes in each direction and a median that connects to Bryan Boulevard at an interchange with NC 68. The proposed Northern Extension project is a divided roadway with two lanes in each direction that connects to the proposed I-40 Connector at an interchange with the proposed I-73/I-74 and Airport Connectors. The location of the Sandy Ridge Road Extension projects are shown in red on Figures 5 (Eastern Extension) and 6 (Northern Extension).

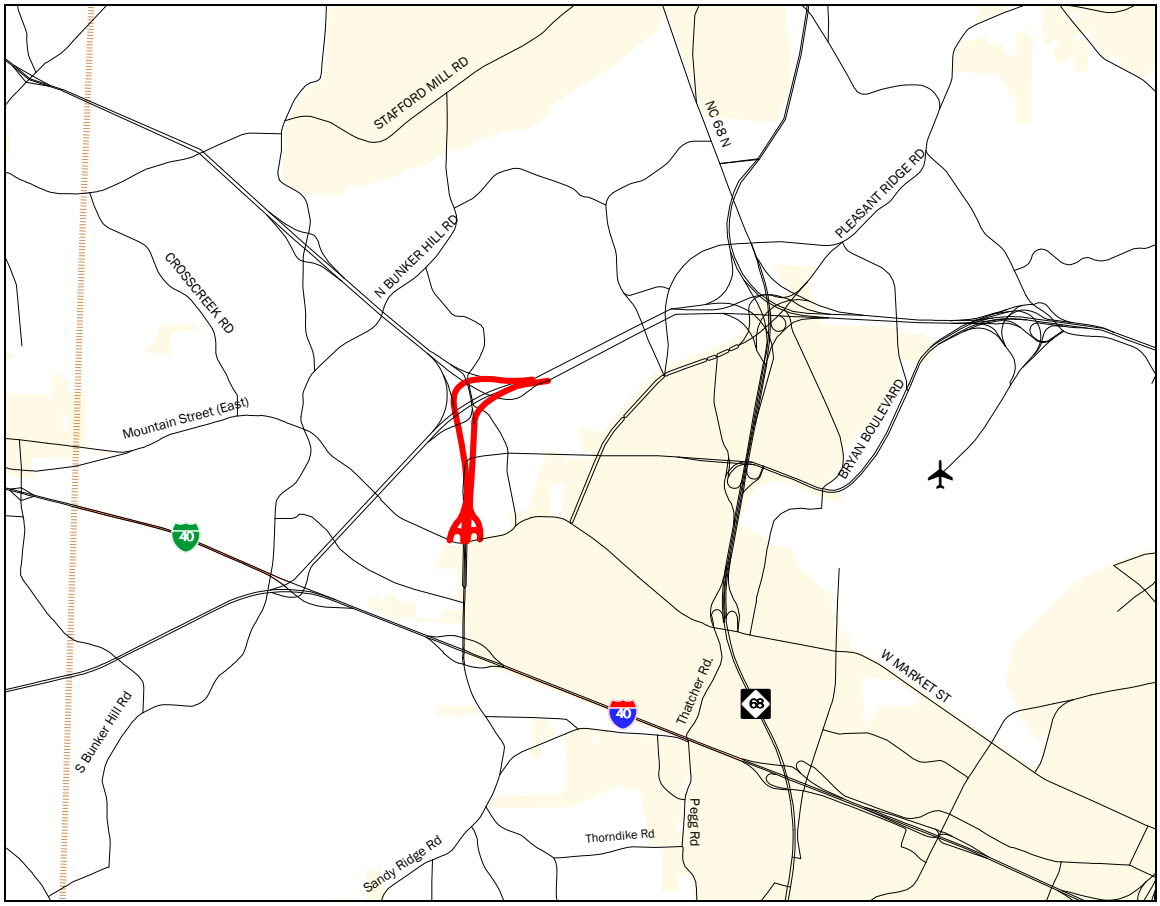
Modeling and analysis of both Sandy Ridge Road extension alternatives assumed a grade separation at West Market Street. An at-grade intersection could also be considered (either as an interim stage or as a final design), yielding substantial right-of way and construction savings.

Figure 5. Sandy Ridge Road Eastern Extension Project Extents



- Project C1 – Sandy Ridge Road Eastern Extension – $40,000,000
- Project C2 – Sandy Ridge Road Northern Extension – $22,768,800

Figure 6. Sandy Ridge Road Northern Extension Project Extents

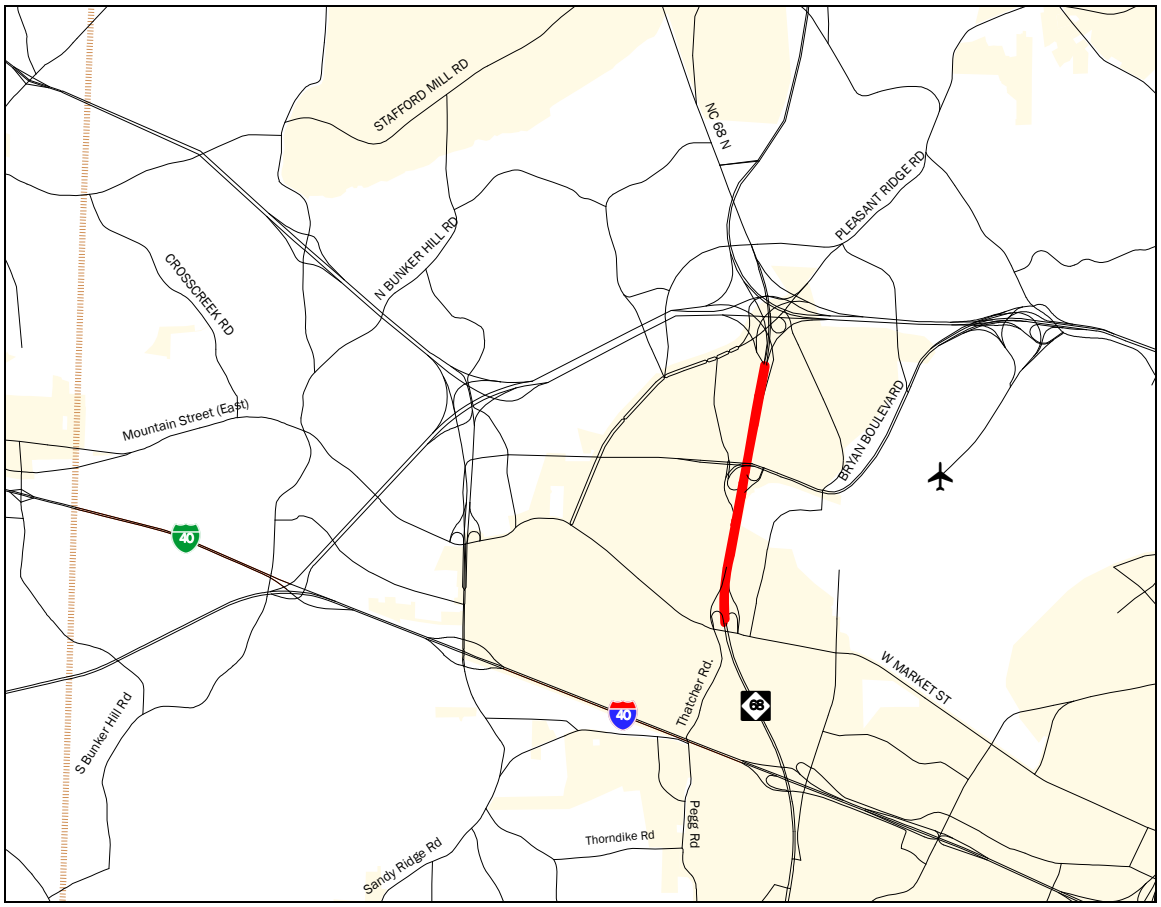


3.4 NC 68 Widening

This project involves widening a portion of NC 68 between West Market Street and Pleasant Ridge Road. The existing NC 68 is a divided highway with two lanes in each direction. The proposed project widens this section to four lanes in each direction. The location of the NC 68 widening project is shown in red on Figure 7.

- Project D1 – Existing NC 68 – $0
- Project D2 – Widened NC 68 – $58,114,585

Figure 7. NC 68 Widening Project Extents

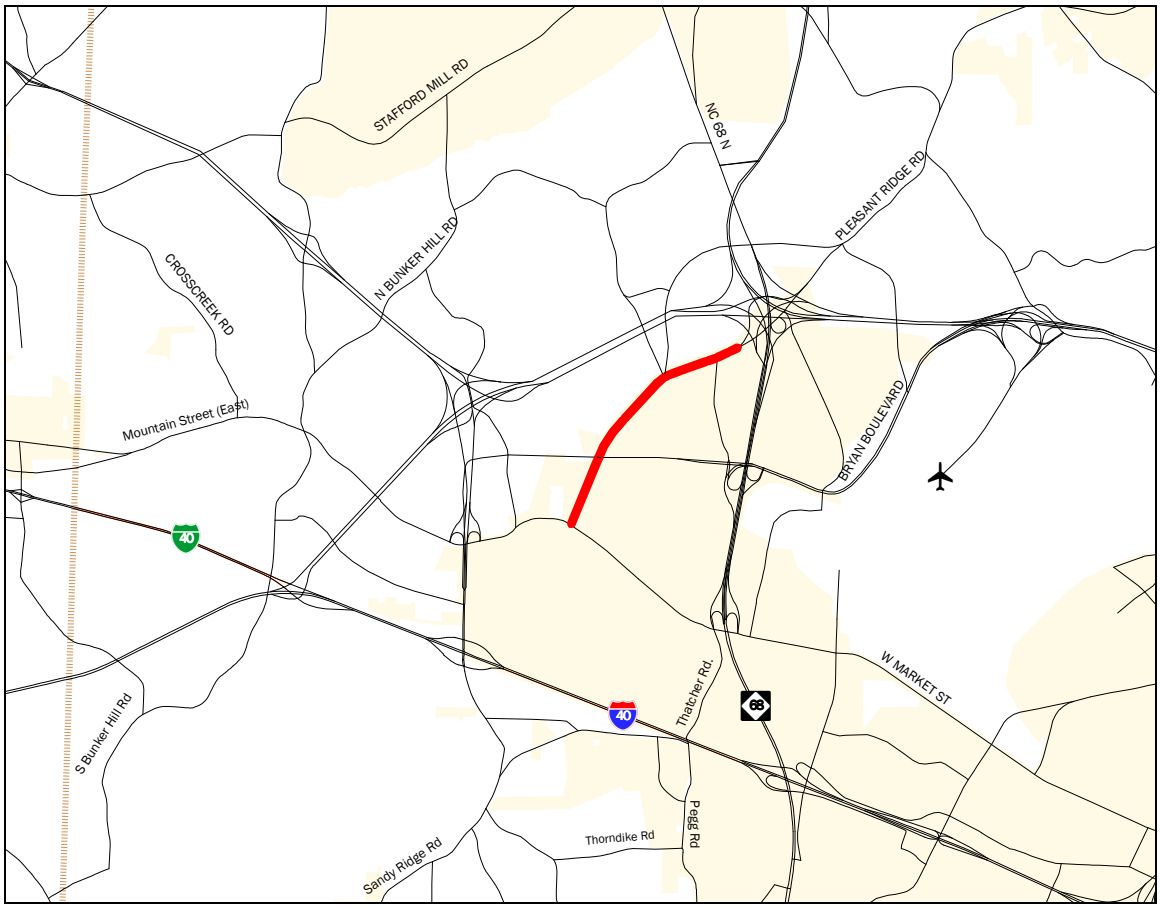


3.5 Pleasant Ridge Road Widening

This project involves widening a portion of Pleasant Ridge Road between West Market Street and Edgefield Road. The existing Pleasant Ridge Road is a rural road with one lane in each direction and no median. The proposed project widens this segment to two lanes in each direction with a median. The location of the Pleasant Ridge Road widening project is shown in red on Figure 8.

- Project E1 – Existing Pleasant Ridge Road – $0
- Project E2 – Widened Pleasant Ridge Road – $13,275,000

Figure 8. Pleasant Ridge Road Widening Project Extents

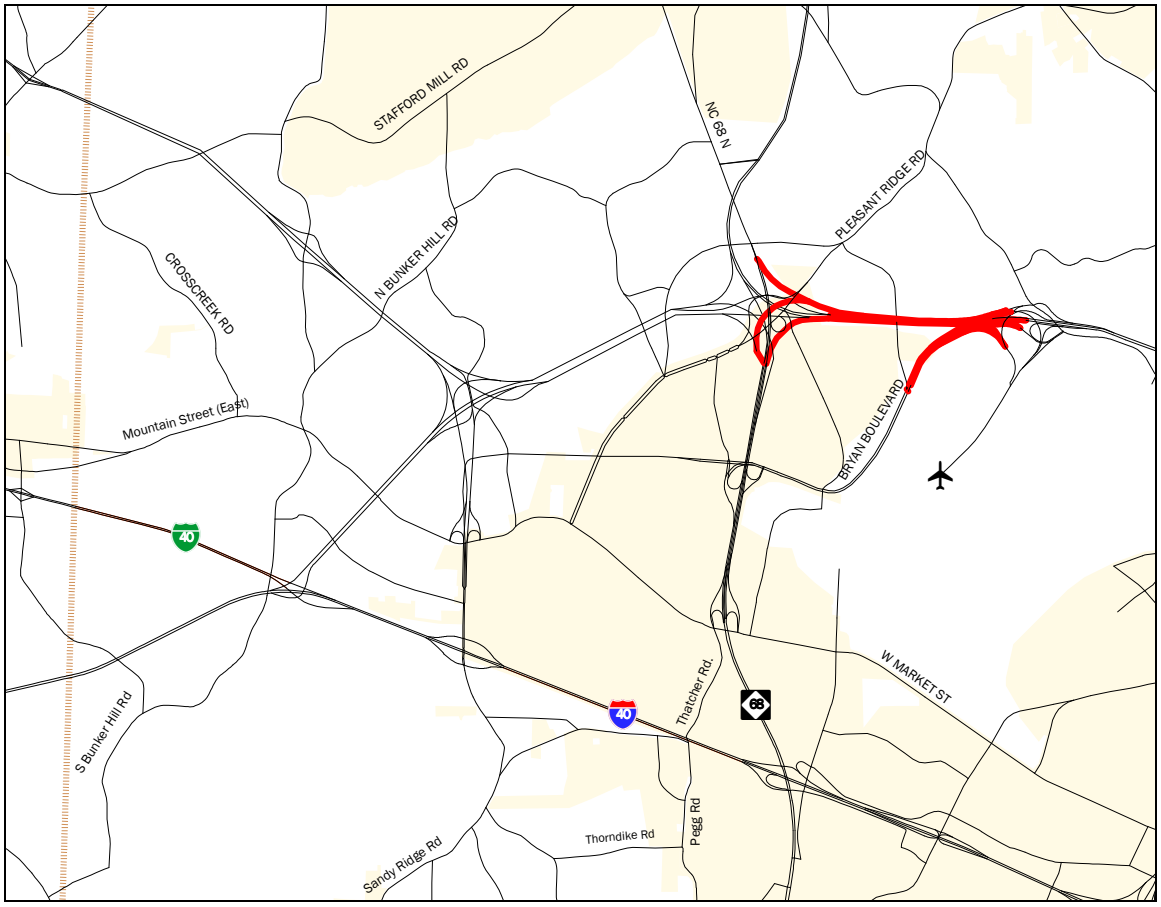


3.6 I-73 Connector

This project involves constructing a new facility between Joseph M. Bryan Boulevard and the future I-73. The proposed project is a divided freeway with two lanes in each direction. The proposed project also includes the removal of a portion of Bryan Boulevard between Caindale Drive and Old Oak Ridge Road. Additionally, the proposed project connects to the future I-73 at an interchange with NC 68 and the proposed Airport Connector. The location of the I-73 Connector project is shown in red on Figure 9.

- Project F1 – Existing Joseph M. Bryan Boulevard – $0
- Project F2 – I-73 Connector – $76,813,560

Figure 9. I-73 Connector Project Extents

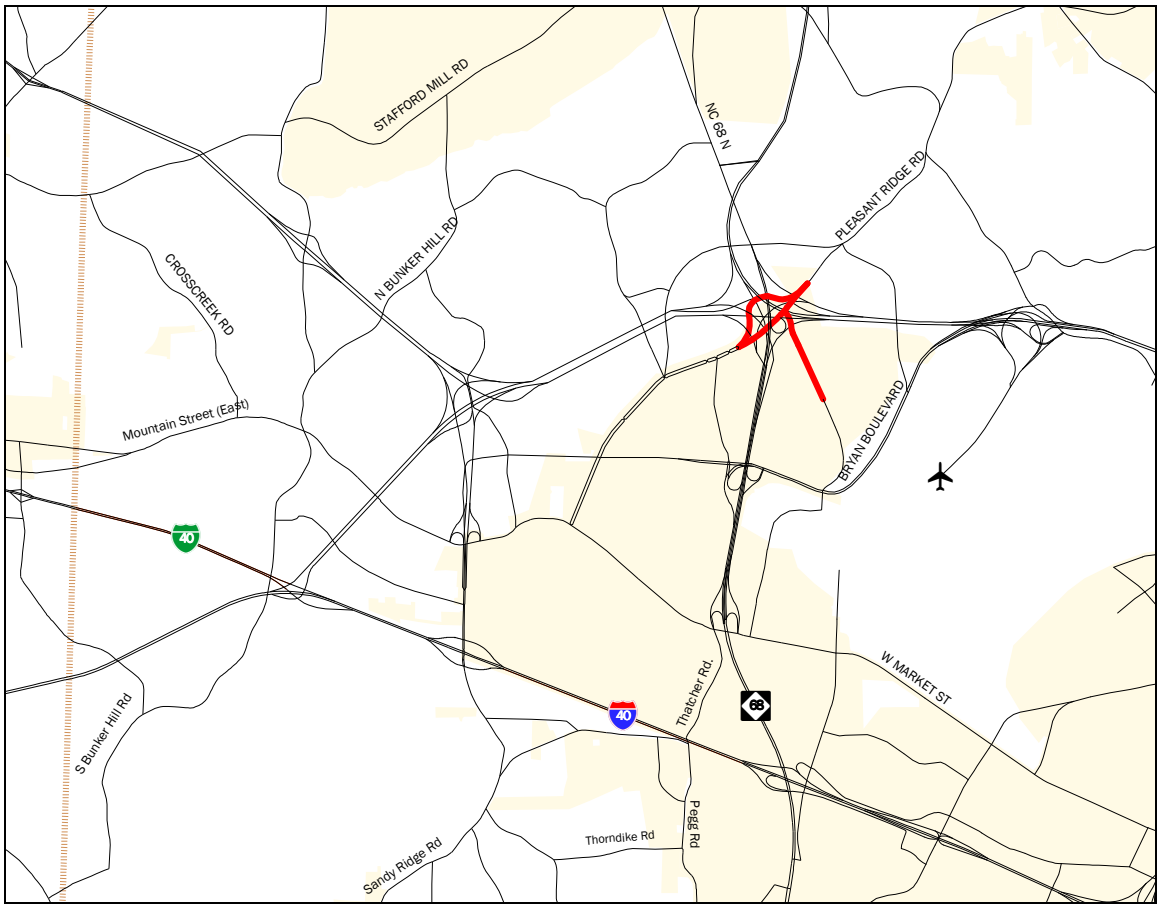


3.7 Pleasant Ridge Road Relocation

This project involves relocating a portion of Pleasant Ridge Road between Brigham Road and North Regional Road to make room for the future I-73/NC 68 interchange. The existing Pleasant Ridge Road is a rural road with one lane in each direction and no median. The proposed project widens the section to two lanes in each direction with a median located north of the current alignment. The project will have an at-grade intersection with NC 68. The location of the Pleasant Ridge Road relocation project is shown in red on Figure 10.

- Project G1 – Existing Pleasant Ridge Road – $0
- Project G2 – Relocated Pleasant Ridge Road – $14,869,268

Figure 10. Pleasant Ridge Road Relocation Project Extents



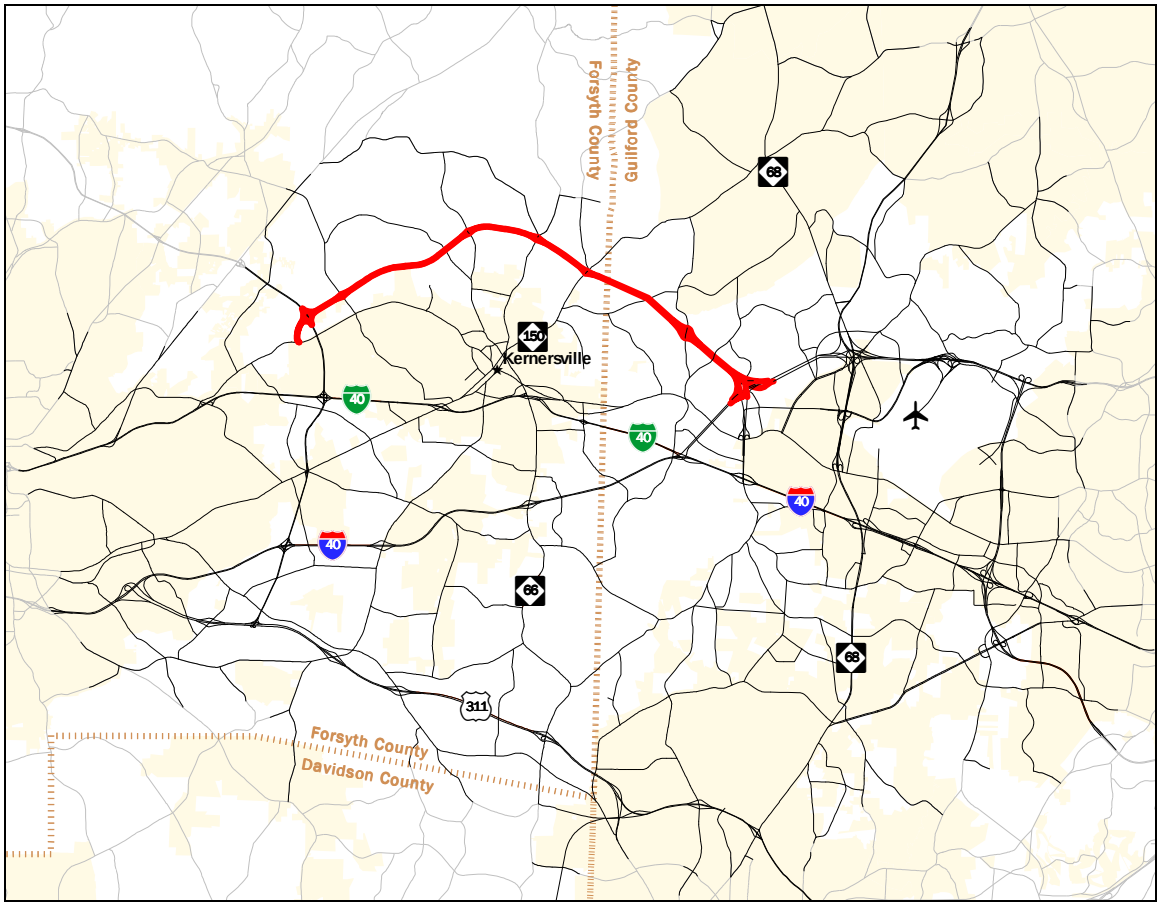
3.8 I-73/I-74 Connector

This project constructs a new facility, also known as the Kernersville Bypass, between West Mountain Street in Winston-Salem and the proposed Airport Connector. The proposed project has two options: 1) a divided freeway with two lanes in each direction or 2) an arterial street with two lanes in each direction and a median. The arterial version substitutes at-grade intersections for five of the seven interchanges in the freeway version, retaining the interchanges at the eastern and western termini.

This project connects to the proposed Airport Connector at an interchange with the proposed I-40 Connector and the Northern Sandy Ridge Road Extension. Note that the cost of this interchange is associated with the I-73/I-74 Connector project, not with the I-40 Connector, as assumed in the GUAMPO LRTP. This change was made to more accurately associate costs with the most appropriate project, given the segmentation of the Airport Connector in this analysis, and the variety of project combinations being assessed. The location of the I-73/I-74 Connector project is shown in red on Figure 11.

- Project H1 – Freeway I-73/I-74 Connector – $388,023,400
- Project H2 – Arterial I-73/I-74 Connector – $314,793,400

Figure 11. I-73/I-74 Connector Project Extents

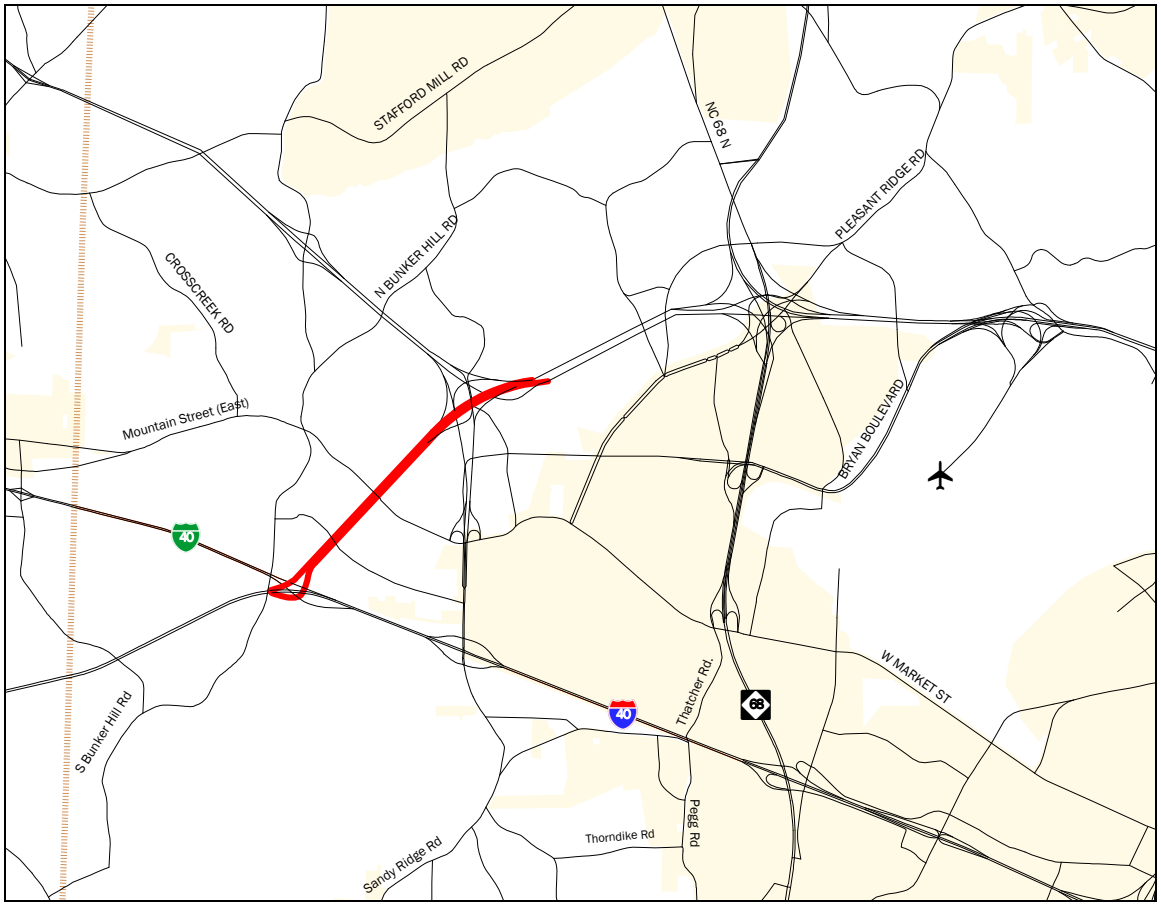


3.9 I-40 Connector

This project involves constructing a new facility between I-40 and the proposed Airport Connector. The proposed project is a divided freeway with two lanes in each direction and also includes the expansion of the I-40/Business I-40 interchange. The proposed project connects to the proposed Airport Connector at an interchange with the proposed I-73/I-74 Connector and Northern Sandy Ridge Road Extension. Note that while the GUAMPO LRTP attributes the cost of this interchange to the I-40 Connector, this analysis associates the cost of the interchange with the I-73/I-74 Connector project. Given the segmentation of the Airport Connector in this analysis, and the variety of project combinations being assessed, this change appears to more accurately associate costs with the most appropriate project. The location of the I-40 Connector project is shown in red on Figure 12.

- Project I – I-40 Connector – $46,354,000

Figure 12. I-40 Connector Project Extents

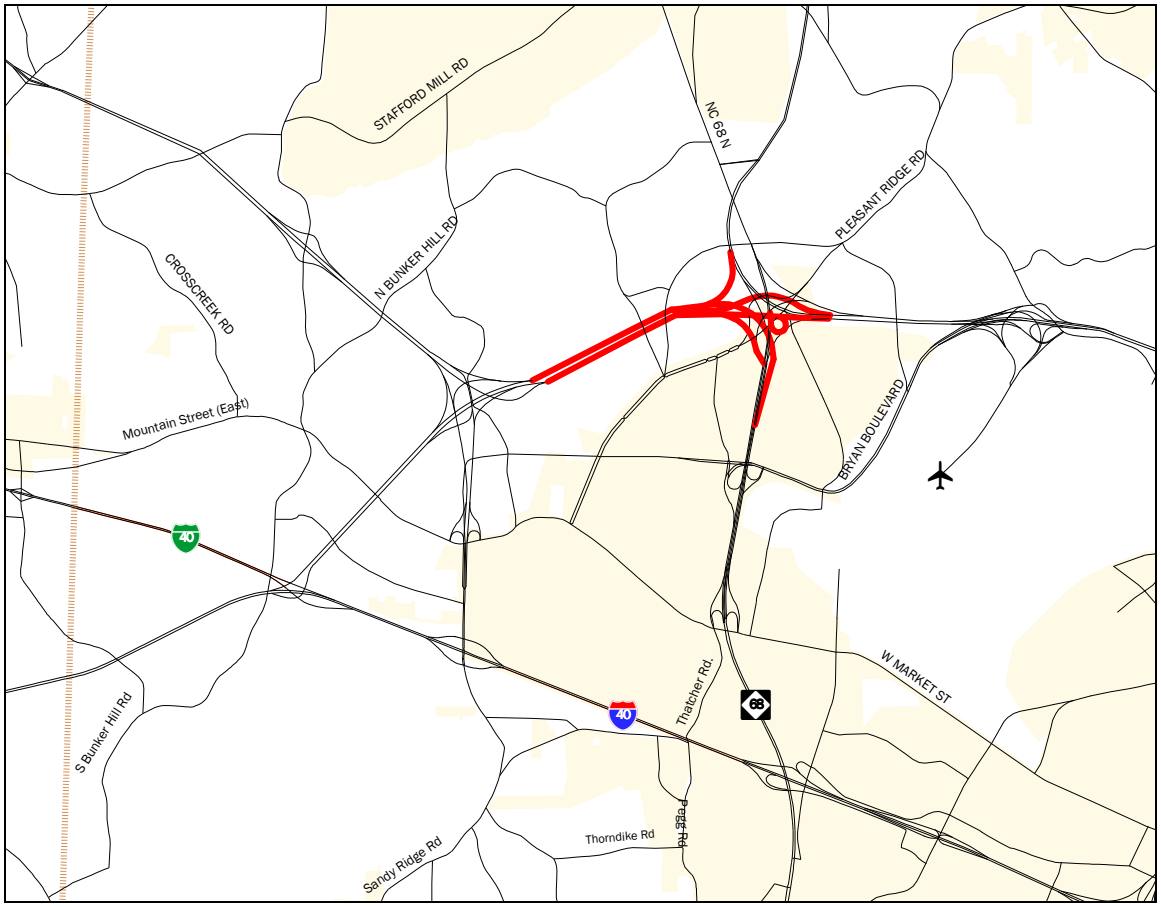


3.10 Airport Connector

This project constructs a new facility between the proposed I-73/I-74 Connector and the proposed I-73 Connector. The proposed project is a divided freeway with two lanes in each direction. This project connects to the proposed I-73/I-74 Connector at an interchange with the proposed I-40 Connector and Northern Sandy Ridge Road Extension. (As previously discussed, the cost of this interchange is associated with the I-73/I-74 Connector). Additionally, the proposed project also connects to the proposed I-73 Connector at an interchange with NC 68 and the future I-73. The location of the Airport Connector project is shown in red on Figure 13.

- Project J1 – Freeway Airport Connector – $23,125,600

Figure 13. Airport Connector Project Extents

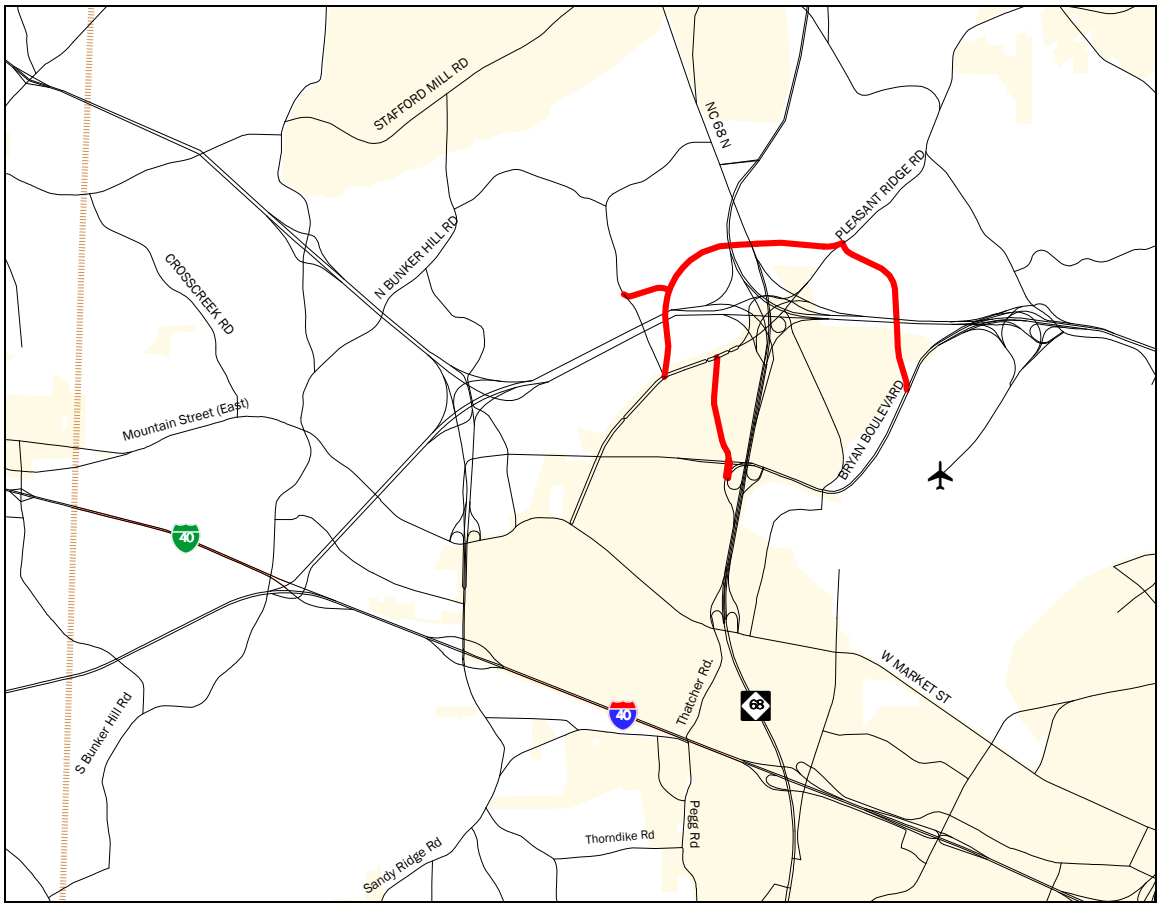


3.11 I-73 Connector Loop Roads

This project involves construction of new facilities to provide local access roads around the future I-73/proposed I-73 Connector/NC 68/proposed Airport Connector interchange. The proposed facilities are rural roads with one lane in each direction and no median. The proposed facilities will connect Joseph M. Bryan Boulevard to Pleasant Ridge Road, Pleasant Ridge Road north of the proposed I-73 Connector to Pleasant Ridge Road south of the proposed Airport Connector, and Pleasant Ridge Road south of the proposed Airport Connector to the proposed Eastern Sandy Ridge Road Extension at the Joseph M. Bryan Boulevard/NC 68 interchange. The location of the I-73 Connector Loop Roads project is shown in red on Figure 14.

- Project K – I-73 Connector Loop Roads – $37,748,635

Figure 14. I-73 Connector Loop Roads Project Extents

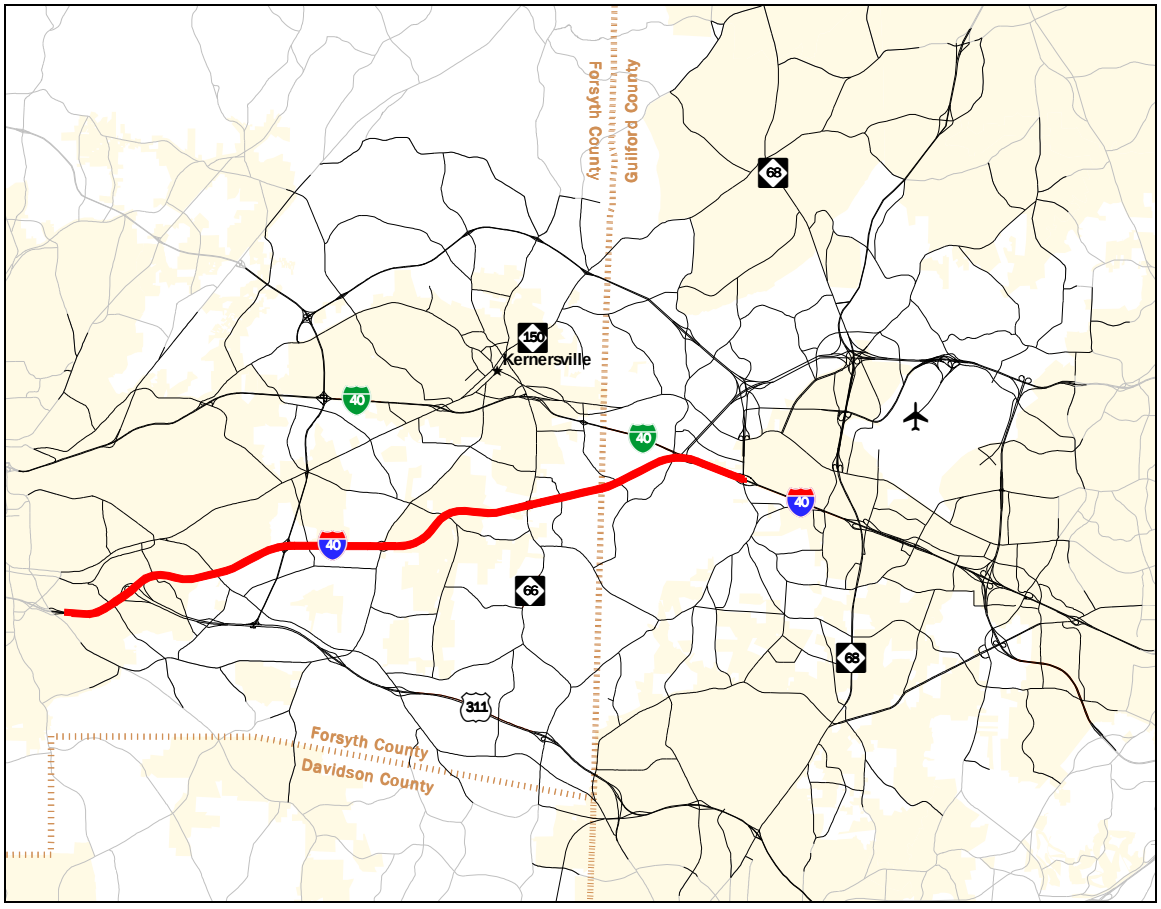


3.12 I-40 Widening

This project involves widening a portion of I-40 between NC 109 in Thomasville and NC 68 in Greensboro. Existing I-40 is a divided freeway with two lanes in each direction between NC 109 and the I-40/Business I-40 interchange and four lanes in each direction between the I-40/Business I-40 interchange and NC 68. The proposed improvements include widening to four lanes in each direction between NC 109 and the I-40/Business I-40 interchange, and widening to five lanes in each direction between the I-40/Business I-40 interchange and NC 68. The proposed project also adds loop ramps at the Old Salem Road/I-40 and Sandy Ridge Road/I-40 interchanges. The location of the I-40 widening project is shown in red on Figure 15.

- Project L1 – Existing I-40 – $0
- Project L2 – Widened I-40 – $444,100,000

Figure 15. I-40 Widening Project Extents



3.13 Evaluation Scenarios

There are 9,214 possible project scenarios, representing every possible combination of the twelve projects, ranging from solely widening Sandy Ridge Road to constructing all of the new projects listed above. The purpose of evaluating all combinations is to understand the cumulative travel benefits of individual projects, as well interactions among multiple projects. For example, both the Sandy Ridge Road widening and Extension projects may have individual benefits, but when constructed in combination, they may have even greater benefit.

4 Travel Demand Model Review

A critical component of the traffic analysis for this project is the preparation of year 2035 subarea traffic forecasts for project scenario testing. Because results from this study will be used for the Sandy Ridge Feasibility Study, it is important that the subarea traffic forecasting approach be consistent with adopted regional data and procedures. This chapter documents the approach for developing year 2035 subarea traffic forecasts using the TransCAD software package.

4.1 Use of the Piedmont Triad Regional Travel Demand Model

A key input into the process is the 2002 approved version of the Piedmont Triad Regional Travel Demand Model. This model utilizes the TransCAD software platform along with recent land use and road network information to forecast the regional demand to 2035. The base year model is calibrated for 2002 conditions and the forecast year model represents 2035 conditions. The model was developed for the entire Piedmont Triad Regional area and includes detailed zone and network systems within Forsyth, Guilford, and Alamance Counties. The model also includes portions of Davidson and Randolph Counties.

4.2 Land Use Assumptions

One of the primary inputs for the PRT TDM is land use data, which is used to estimate trip generation information. Land use information is summarized within traffic analysis zones (TAZs), which represent geographical boundaries that contain many individual parcels. The PRT TDM employs eight land use data categories for each TAZ:

- Households
- School Students
- Highway Retail Employees
- Industrial Employees
- Retail Employees
- Service Employees
- Office Employees
- School Employees

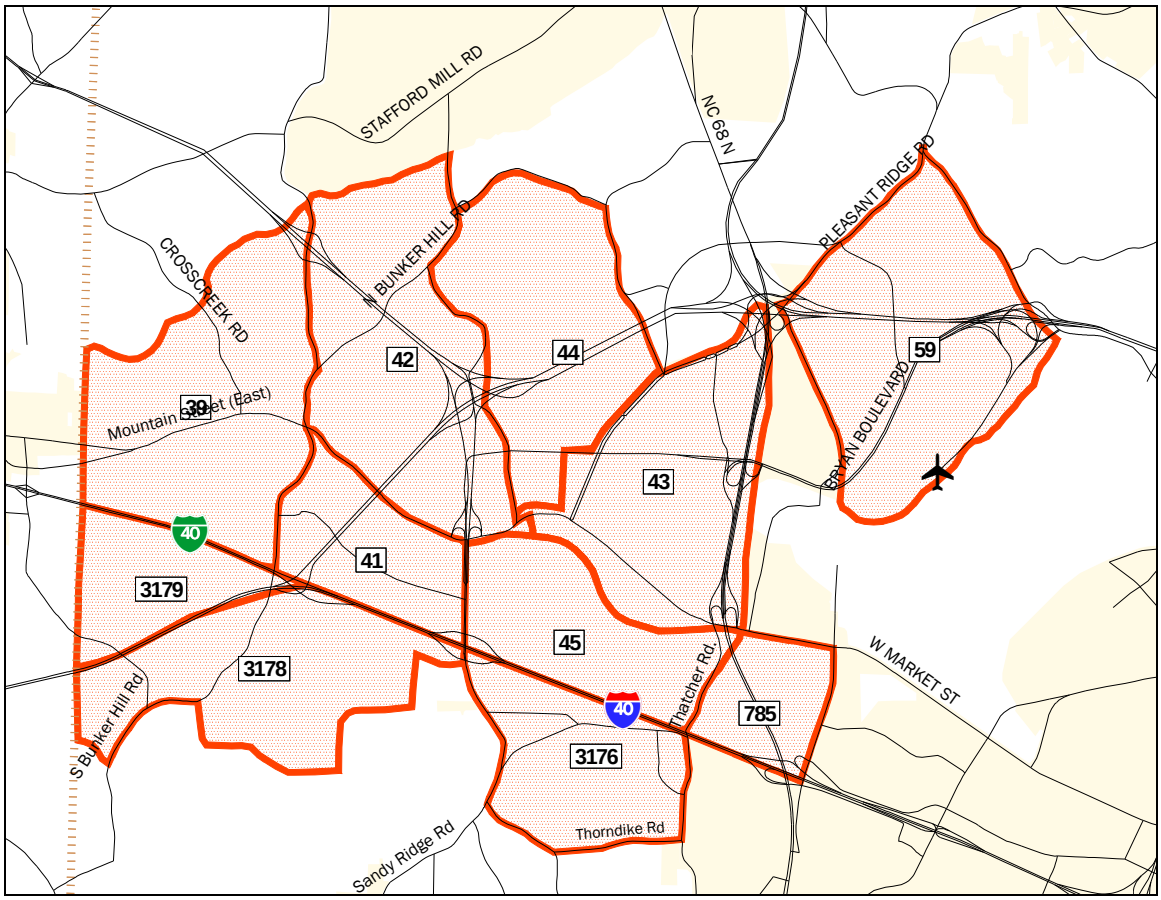
For the purposes of this study, the land use data contained in the approved 2009 and 2035 Existing + Committed (E+C) scenarios was used. However, the land use forecast within the PTIA area was thoroughly reviewed by GUAMPO staff and adjusted to account for recent development proposals that could significantly affect the future transportation network planning in the area.

GUAMPO staff recommended changes within the PTIA area, which were included in the land use assumptions for the 2035 model runs, as shown in Table 2 and Figure 16:

Table 2. 2035 Land Use Changes

TAZ	HH	HWY RET	IND	RETAIL	SERVICE	OFFICE	SCHOOL
Existing 2035 Data							
39	0	0	438	21	61	57	0
41	92	412	0	260	391	0	0
42	467	9	509	147	561	0	107
43	0	0	3,329	430	1,318	0	0
44	407	26	432	225	232	84	0
45	0	141	2,714	3,046	1,096	1,298	0
59	0	39	2,887	1,064	3,256	1,662	0
785	0	0	2,124	1,667	3,024	433	0
3176	0	0	634	2,749	1,386	463	0
3178	0	193	7	514	1,181	50	0
3179	0	0	0	0	0	0	0
Land Use Changes							
39	0	0	+380	+18	+53	+49	0
41	+500	+2,294	0	+1,448	+2,178	0	0
42	-300	+17	+966	+279	+1,065	0	+203
43	0	0	-1,134	-146	-449	0	0
44	-200	+66	+1,094	+570	+587	+213	0
45	0	-60	-1,146	-1,287	-463	-548	0
59	0	-9	-648	-239	-731	-373	0
785	0	0	-1,245	-977	-1,772	-254	0
3176	0	0	-12	-53	-26	-9	0
3178	0	-10	0	-26	-61	-3	0
3179	0	0	+100	+64	+30	+6	0
Airport Area Study 2035 Data							
39	0	0	818	39	114	106	0
41	592	2,706	0	1,708	2,569	0	0
42	167	26	1,475	426	1,626	0	310
43	0	0	2,195	284	869	0	0
44	207	92	1,526	795	819	297	0
45	0	81	1,568	1,759	633	750	0
59	0	30	2,239	825	2,525	1,289	0
785	0	0	879	690	1,252	179	0
3176	0	0	622	2,696	1,360	454	0
3178	0	183	7	488	1,120	47	0
3179	0	0	100	64	30	6	0

Figure 16. 2035 Land Use Changes TAZ Map



4.3 Roadway Network Assumptions

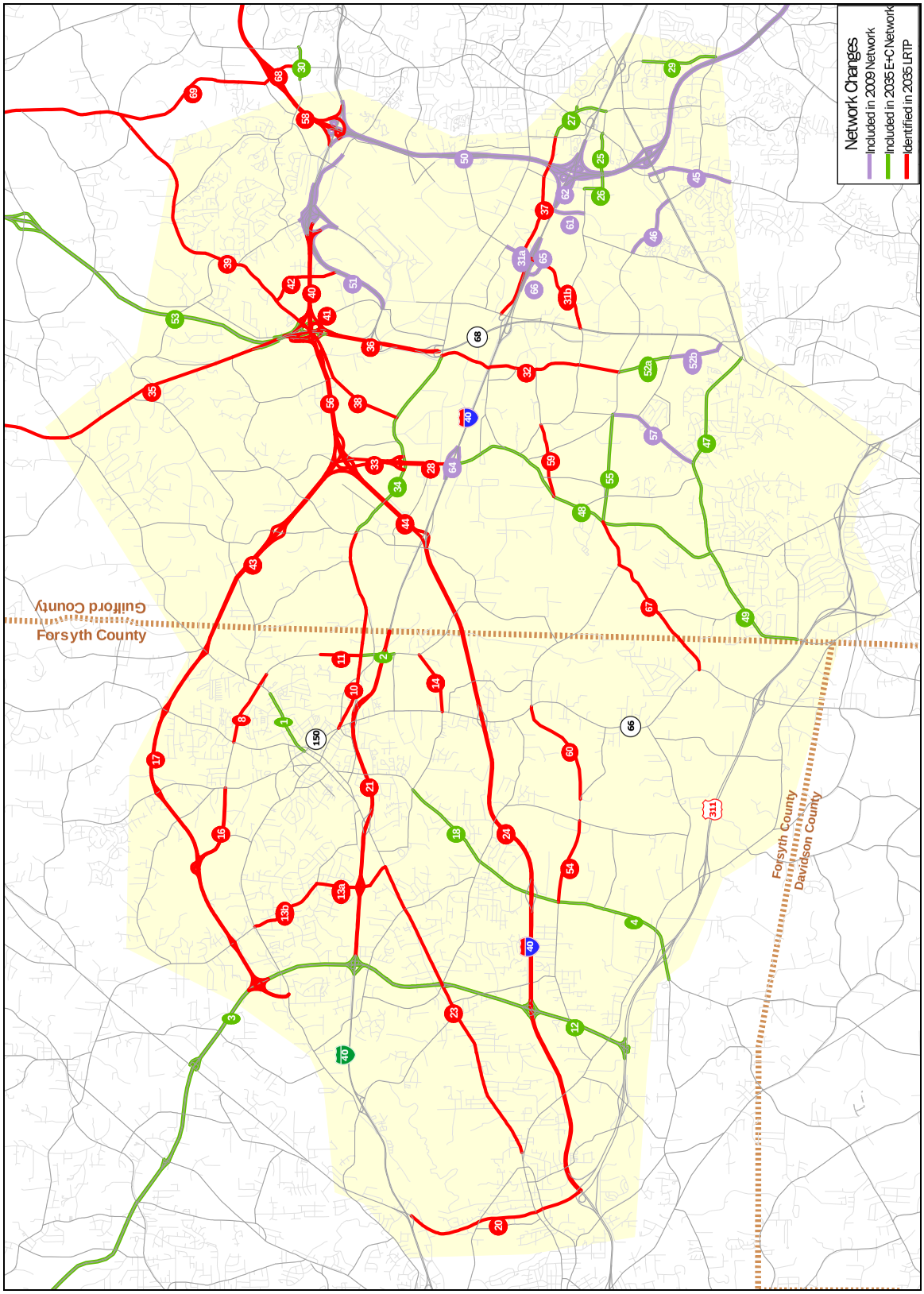
The roadway network for the 2009 and 2035 E+C conditions is based on the 2008 approved model roadway centerline file. The model roadway networks include all state routes, arterials, collectors, and important local roads within the study area. The roadway network database includes street name, distance, and generalized functional class. In addition to these attributes, speed, capacity, number of lanes, median presence, and signals per mile were coded. The roadway attributes are used by the travel demand model to estimate the vehicular capacity for each roadway segment.

The 2009 model roadway network represents existing conditions and includes only roadways operational in 2009. The 2035 E+C model roadway network includes both existing roadways and roadway projects with funding commitments that are anticipated to be operational by 2035. There are a number of proposed roadway improvements in the PTIA area that are accommodated in the forecasting process based on input from the Steering Committee. The Piedmont Triad Regional Travel Demand Model was inspected and modified to ensure that the 2035 roadway network included the improvements listed in Table 3 and shown on Figure 17. Projects identified in the area 2035 LRTPs are also listed in the table and figure, which include the twelve projects under evaluation in the PTIA area.

Table 3. Network Changes Description

ID	Project Name	Project Limits	Existing	Proposed
		Included in 2009 Network		
31a	Gallimore Dairy Road	International Drive to Albert Pick Rd	2 lane	4 lane divided
45	Guilford College Road (SR 1546)	High Point Rd (SR 4121) to south of Wendover Ave (SR 1541)	2 lane	4 - 5 lane
46	Piedmont Parkway Extension	Tarrant Road to W. Wendover Avenue		4 lane divided
50	I-840	Bryan Boulevard to I-85		6 lane freeway
51	Bryan Boulevard Extension / Relocation	Old Oak Ridge Road to Regional Road		4 lane freeway
52b	Penny Road	NC 68 to Willard Dairy Road		4 lane divided
57	Barrow Road	Clinard Farms Road to Skeet Club Road		4 lane divided
61	Boulder Road	Chimney Rock Road to Burnt Poplar Rd		2 lane undivided
62	Chimney Rock Road	Hornaday Road Extension to Burnt Poplar Rd	2 lane	remove road
64	Sandy Ridge Road Ramps to I-40	I-40 at Sandy Ridge Road	ramps	standard diamond
65	Gallimore Dairy Road Ramps to I-40	I-40 at Gallimore Dairy Road		diamond and butterfly ramps
66	Albert Pick Road	Albert Pick Road to Gallimore Dairy Road (relocation)	2 lane	2 lane undivided
		Included in 2035 E+C Network		
1	North Main Street (NC 150)	NC66 to Clay Flynt Road		3 lane
2	SR 2601 (Macy Grove Road)	New Location and Convert Grade Separation at I-40 Business to an Interchange.		Build Interchange ; 4 lane divided
3	74)	(Reidsville Road)		New 4 - 6 lane freeway
4	Union Cross Road (SR 2643)	I-40 to High Point Road	2 lane	3 lane and 4 lane divided
12	74)	(Reidsville Road) to US 52)		New 4-6 lane divided
18	Union Cross Road (SR 2643)	Widening from Wallburg Road (SR 2691) to Whicker Road (SR 2640)	2-3 lane	4 lane divided
25	Hornaday Road Extension	Hornaday Road to Chimney Rock Road		3 lane
26	Hornaday Road Bridge	Grade Separation over Greensboro Urban Loop		3 lane
27	Bridford Parkway Extension	Hornaday Road to Burnt Poplar Road		4 lane divided
29	Stanley Road	Koger Boulevard to Hilltop Road	2 lane	5 lane
30	Horsepen Creek Rd / Fleming Rd Connector	Isaacson Boulevard to Inman Road		4 lane divided
34	West Market Street	Bunker Hill Road to NC 68	2 lane	4 lane divided
47	Skeet Club Road	NC 68 to Johnson Street	2 lane	4 - 5 lane
48	Johnson Street/Sandy Ridge Road	Skeet Club Road to I-40	2 lane	4 lane divided
49	Skeet Club Road	Johnson Street to US 311	2 lane	4 - 5 lane
52a	Penny Road	Willard Dairy Road to Clinard Farms Road		4 lane divided
53	NC 68 / US 220 Connector	NC 68 to US 220		4 lane freeway
55	Piedmont Parkway Extension	Johnson Street to Barrow Road		4 lane divided
		Identified in 2035 LRTP		
8	N. Main St./Piney Grove Rd. Connector	North Main Street (NC 150) to Piney Grove Road (SR 1969)		New 4 lane divided
10	1008	NC 66 to SR 2001 (Winthrop Street) in Guilford County. Widen to Multi-Lanes.	2 lane	5 lane
11	Macey Grove Road Extension (North)	SR 1005 (East Mountain Street) to NC 150 (North Main Street).		New 4 lane divided
13a	Business I-40 (US 421) Interchange at Big Mill Farm Road	Hopkins Road to S. Main Street		New Interchange 4 lane divided
13b	Business I-40 (US 421) Interchange at Big Mill Farm Road	Hopkins Road to NC 66		4 lane divided
14	Macey Grove Road Extension (South)	NC 66 to Industrial Park Drive		New 4 lane divided
16	Linville Springs Road (SR 2030) Extension	Piney Grove Road (SR 1969) to I-73/74 Connector (Regional Aiport Connector)		New 4 lane divided
17	I-73 - I-74 Connector	Northern Beltway/West Mountain Street to Guilford County		New 4 lane freeway
20	US 311 Connector	I-40 to Business I-40		New 4 lane divided
21	Business I-40 (US 421)	Northern Beltway to Guilford County	4 lane freeway	6 lane freeway
23	Kernersville Road (SR 4315)	High Point Road (SR 1003) to Whicker Road	2 lane	3 lane
24	I-40	US 311 to Business 40 Split	4 lane freeway	6 lane freeway
28	Sandy Ridge Road	I-40 to West Market Street	2 lane	4 lane divided
31b	Gallimore Dairy Road	NC 68 to Albert Pick Rd	2 lane	4 lane divided
32	Pegg / Thatcher Connector	W Market Street to Clinard Farms Rd		4 lane divided
33	Sandy Ridge Road Extension	West Market Street to I-40 / NC 68 / I-73 Connector		4 lane divided
35	NC 68	Peeples Road to Rockingham County	2 lane	4 lane divided
36	NC 68	Market Street to Pleasant Ridge Road	4 lane	6 lane divided
37	Burnt Poplar Road	Swing Road to Regional Road	2 lane	3 lane
38	Pleasant Ridge Road	West Market Street to City Limits	2 lane	4 lane divided
39	Pleasant Ridge Road	City Limits to Old Oak Ridge Rd	2 lane	4 lane divided
40	I-73 Connector	NC 68 to Bryan Boulevard		4 lane freeway
41	Pleasant Ridge Road Relocation at I-73 Connector	Montmartre Road to Cude Road		3 lane
42	Bryan Boulevard Loop at I-73 Connector	Montmartre Road to Pleasant Ridge Road		4 lane divided
43	I-73 - I-74 Connector	Forsyth County to NC 68		4 lane divided
44	I-40 Connector	I-40 to I-73 / I-74 Connector		4-6 lane freeway
54	Glenn High Road Extension	Union Cross Road to Teague Lane		4 lane divided
56	Airport Connector	I-73 - I-74 Connector to NC 68		4 lane freeway
58	I-840	Bryan Boulevard to US 220 / US 29		6 lane freeway
59	Thorndike Road	Gallimore Dairy Road to Sandy Ridge Road		2 lane undivided
60	Bunker Hill Sandy Ridge Road	NC 66 to Teague Lane		4 lane divided
67	Winston-Salem North/South Connector	NC 66 to Johnson Street on Squire Davis Road / Sandy Ridge Road	2 lane	4 lane undivided
68	Flemington-Lewiston Connector	Fleming Road to Lewiston Road Connection		4 lane divided
69	Lewiston Road / Pleasant Ridge Road	Urban Loop to NC 150 Relocation	2 lane	4 lane divided

Figure 17. Network Changes Map



4.4 Performance Testing

Model validation is the term used to describe how closely the model's output matches existing travel data in the base year. The 2008 approved model met NCDOT travel demand model validation guidelines, and base year performance was deemed acceptable. However, the NCDOT validation guidelines measure only the model's ability to replicate a static set of conditions (traffic counts). While this provides useful information, its value is limited because the purpose of this study is to forecast how changes in the roadway network would change traffic conditions.

A more valid test of a model's accuracy would focus on the model's ability to predict realistic differences in outputs as inputs are changed; in other words, dynamic validation rather than static validation. In order to review the model's dynamic validation within the PTIA area, the following two tests were performed.

The first test was to see how the model responds to the removal of a link in the road network. For this test, a critical north-south connection was removed, NC 68 between the I-40 on- and off-ramps. Table 4 summarizes the results of this test. The majority of traffic is rerouted to the four parallel connections. As would be expected, there is a small drop in total traffic, since increased congestion and less direct access across I-40 shifts some of the trips to other crossing points along I-40 outside of the testing area.

Table 4. Removal of a Link in the Network

I-40 Overcrossing	With NC 68	Without NC 68	Ratio
Sandy Ridge Road	15,187	20,189	1.33
NC 68 NB	14,565	0	n/a
NC 68 SB	16,497	0	n/a
Gallimore Dairy Road	11,065	22,277	2.01
South Regional Road	7,851	8,808	1.12
Chimney Rock Road	12,890	13,730	1.07
Total	**78,055**	**65,004**	**0.83**

The second test assessed the model response to adding a link to the road network. For this test, the proposed Pegg Road/Thatcher Road extension under I-40 was added. Table 5 summarizes the results of this test. Again, as would be expected, traffic decreases on the five parallel roadways and is rerouted to take advantage of the new capacity on Thatcher Road. In addition, there is a small increase in the total amount of traffic, due to the induced demand of additional roadway facilities.

Table 5. Addition of a Link to the Network

I-40 Overcrossing	Without Thatcher Road Connection	With Thatcher Road Connection	Ratio
Sandy Ridge Road	15,187	12,377	0.81
Thatcher Road	0	6,812	n/a
NC 68 NB	14,565	14,296	0.98
NC 68 SB	16,497	14,890	0.90
Gallimore Dairy Road	11,065	10,195	0.92
South Regional Road	7,851	7,235	0.92
Chimney Rock Road	12,890	12,806	0.99
Total	**78,055**	**78,611**	**1.01**

The results of the dynamic validation tests confirm that the model produces reasonable results for the model application this study requires.

5 Travel Demand Model Forecasting Methodology

This chapter describes the methodology used to develop traffic forecasts for the various projects in the PTIA area. Each step is described in more detail below.

5.1 2035 E+C Model Base Run

A full execution of the Piedmont Triad Regional Travel Demand Model requires approximately twelve hours to complete, while the traffic assignment portion alone requires approximately two hours. Given the number of scenarios that are under evaluation, it would take approximately twelve years to fully execute the model for each scenario. For these reasons, the use of a subarea model representing a smaller geographic portion of the Piedmont Triad Regional Travel Demand Model was selected for this study.

In support of this approach, the 2035 E+C Piedmont Triad Regional Travel Demand Model was run with the land use and roadway network changes described in the previous chapter to develop the baseline origin-destination information for the subarea model. The PM peak hour subarea origin-destination trip tables from the 2035 E+C Piedmont Triad Regional Travel Demand Model were extracted for use in the subarea model.

5.2 Subarea Model Development

To decrease the time required to perform individual scenario runs, the full Piedmont Triad Regional Travel Demand Model was used for the trip generation, trip distribution, and mode choice steps, while the subarea model was used for traffic assignment steps within the project study area. Additionally, the traffic assignment step within the subarea was further streamlined by collapsing the number of vehicle classification bins from 14 (single occupant vehicle, single occupant vehicle toll, high-occupancy vehicle 2, high-occupancy vehicle 2 toll…) to two (personal vehicle and commercial/heavy vehicles). The resulting subarea model required approximately 30 seconds to complete the traffic assignment step within the study area.

5.3 Subarea Model Scenario Runs

A subarea model batch routine was created to execute the traffic assignment step for all of the project scenarios. This took approximately 77 hours to complete using the origin-destination information from the full 2035 E+C Piedmont Triad Regional Travel Demand Model. Twenty-five sets of the resulting traffic forecasts data were reviewed in detail to ensure that the project scenarios were correctly coded and that the resulting traffic forecasts were reasonable.

6 Subarea Model Results

6.1 Traffic Statistics

The travel demand forecasting for this project was accomplished using a combination of the most recent Piedmont Triad Regional Travel Demand Model (with land use and roadway network modifications as previously described) and a subarea travel demand model representing a portion of the model within the PTIA area.

It is important to recognize that regional models such as the Piedmont Triad Regional Travel Demand Model typically represent only major components of the roadway network and are calibrated/validated to the level of screenlines and major corridor volumes. These models are best-suited to forecast regional-level traffic patterns, and usually lack sufficient detail to provide reasonable forecasts at the intersection turning movement level.

As a result, specific traffic volumes were not used as performance measures; rather the following aggregate statistics were calculated over the entire subarea for each scenario:

- Vehicle miles traveled (VMT)
- Vehicle hours traveled (VHT)
- Vehicle hours of delay (VHD)

While each measure is a standard aggregate reporting statistic for travel demand model work and is helpful for comparing scenarios against each other, VHD was selected as the most meaningful statistic for this study because it directly measures traffic congestion. Specifically, it indicates the additional time spent on the network due to other traffic.

VHD is inversely related to user benefit; a reduction in VHD results in reduced travel time and decreased idle time, which saves money and lessens pollutants. Alternatively, VMT and VHT are not directly related to user benefit; while an increase in VMT or VHT does lead to increased travel and mobility, the additional travel also results in increased air pollution and promotes non-dense development patterns. Furthermore, changes in VMT and VHT are more beneficial to longer trips, which are typically regional in nature (especially along I-40 through the study area).

6.2 Evaluation Criteria

As noted in the first chapter, the purpose of this study is to evaluate the various proposed roadway projects and alternatives in the PTIA area. The evaluation of these projects will improve GUAMPO's decision-making by providing objective and comparative measures of project performance. This performance includes traffic statistics along with cost information, provided earlier in the report. The following section provides benefit/cost analysis information that provides insight into the return on investment for the different projects. Ultimately, this information is most useful for designing a project implementation plan intended to meet specific GUAMPO objectives.

6.3 Project Scenario Analysis

The model data and cost information were combined to create the following variables:

- Projects – Number of individual projects included in each scenario, ranging from one to twelve.
- Cost (Million) – Total cost of the projects included in each scenario, in millions of dollars.
- VHD Reduction – Difference in VHD between each scenario and the base scenario (2035 E+C network, no scenario projects).
- VHD Reduction/Project – Total VHD reduction per number of projects included in each scenario.
- VHD Reduction/Cost (Million) – Total VHD reduction per scenario cost.

Due to the large number of scenarios under evaluation, the initial screening of scenario performance involved the creation of Figures 18 through 22, which compare the scenario variables by highlighting different relationships.

Figure 18 compares the scenario cost with its corresponding VHD reduction. As shown on the figure, almost all scenarios result in a VHD reduction from the base case (2035 E+C: 15,047 VHD), with a maximum reduction of approximately 6,100 VHD.

Figure 18. Cost (Million) vs. VHD Reduction

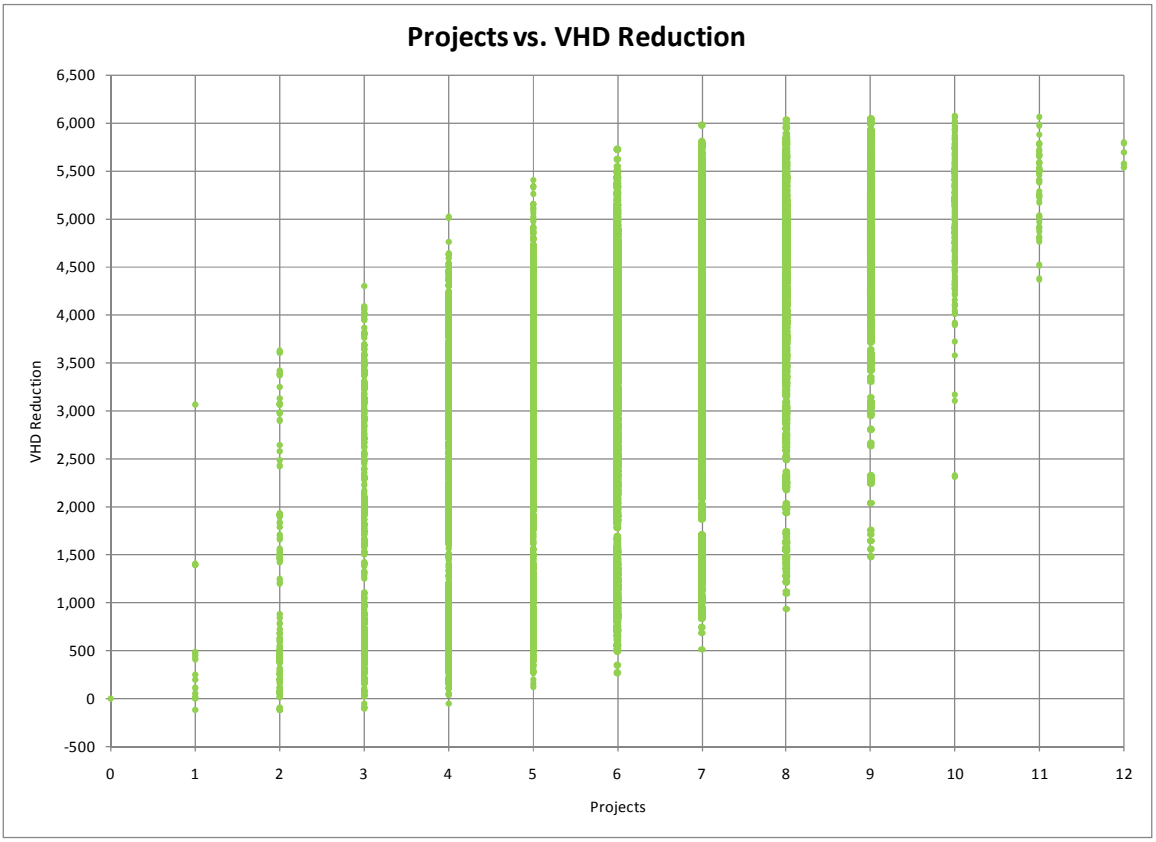
actually increase VHD (These scenarios include projects that may eliminate a bottleneck in one area, only to move it to another, more constrained location). The most interesting finding from this figure is the tradeoff between cost and VHD reduction.

While the general trend indicates increasing cost yields a higher VHD, there is a wide range of performance at each cost increment. For example, spending approximately $600 million can generate a VHD reduction ranging from approximately 2,200 to 5,000, depending on which specific projects are built. This result indicates that the combination of projects (especially complimentary projects such as the I-73 Connector and the Airport Connector) has more influence on VHD reduction than does the total cost of the scenario.

Figure 18 also begins to reveal the issue of diminishing returns -- a topic covered in more detail in the discussion of Figure 21. For example, doubling the infrastructure investment by adding a second $600 million in projects yields only 20% of the delay reduction obtained from the first $600 million investment (assuming that $600 million was optimally spent).

Figure 19 organizes results by comparing the number of projects in a scenario to the VHD reduction. The general trend indicates that the more projects a scenario has, the larger the VHD reduction. That being said, the specific combination of projects can result in drastically different VHD reduction levels. For example, scenarios with seven projects can result in VHD reductions between approximately 500 and 6,000. These results further confirm that the specific combination of projects is the most important predictor of VHD reduction, even more important than the number of projects.

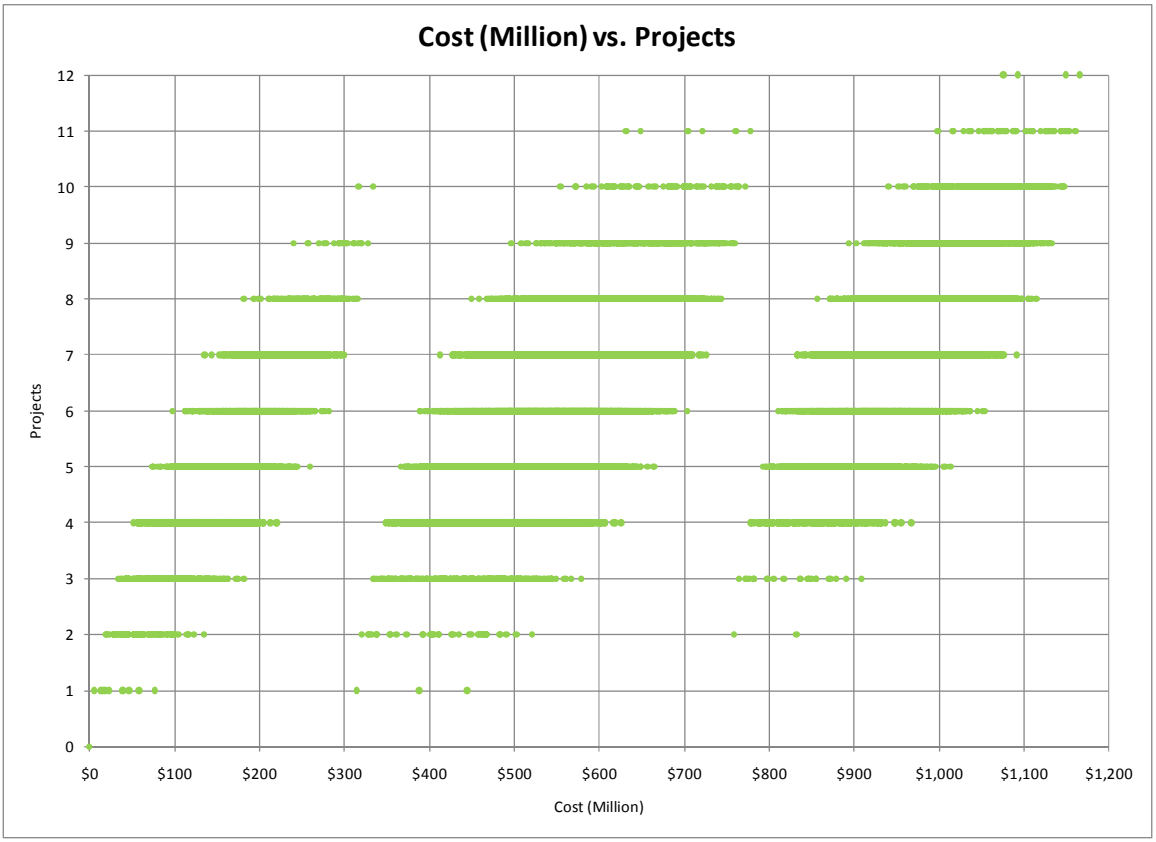
Figure 19. Projects vs. VHD Reduction



It should also be noted that the scenario yielding the highest VHD reduction (approximately 6,100) includes only ten projects. Adding an eleventh or twelfth project results in a lower VHD reduction, indicating that, while they may provide additional roadway capacity or routing options, some of these projects are redundant, especially when constructed with a host of other projects.

Figure 20 compares the cost of each scenario to the number of projects constructed. There is no clear relationship between the cost of a scenario and the number of projects. It may be expected that the number of projects in a scenario should increase with the total cost. This is not the case in the PTIA area due to huge cost differences between individual projects, specifically freeway projects versus local roadway projects. For example, spending approximately $440 million allows for a scenario that constructs only the I-40 widening project, while spending approximately $250 million allows for a scenario that constructs nine separate, smaller projects.

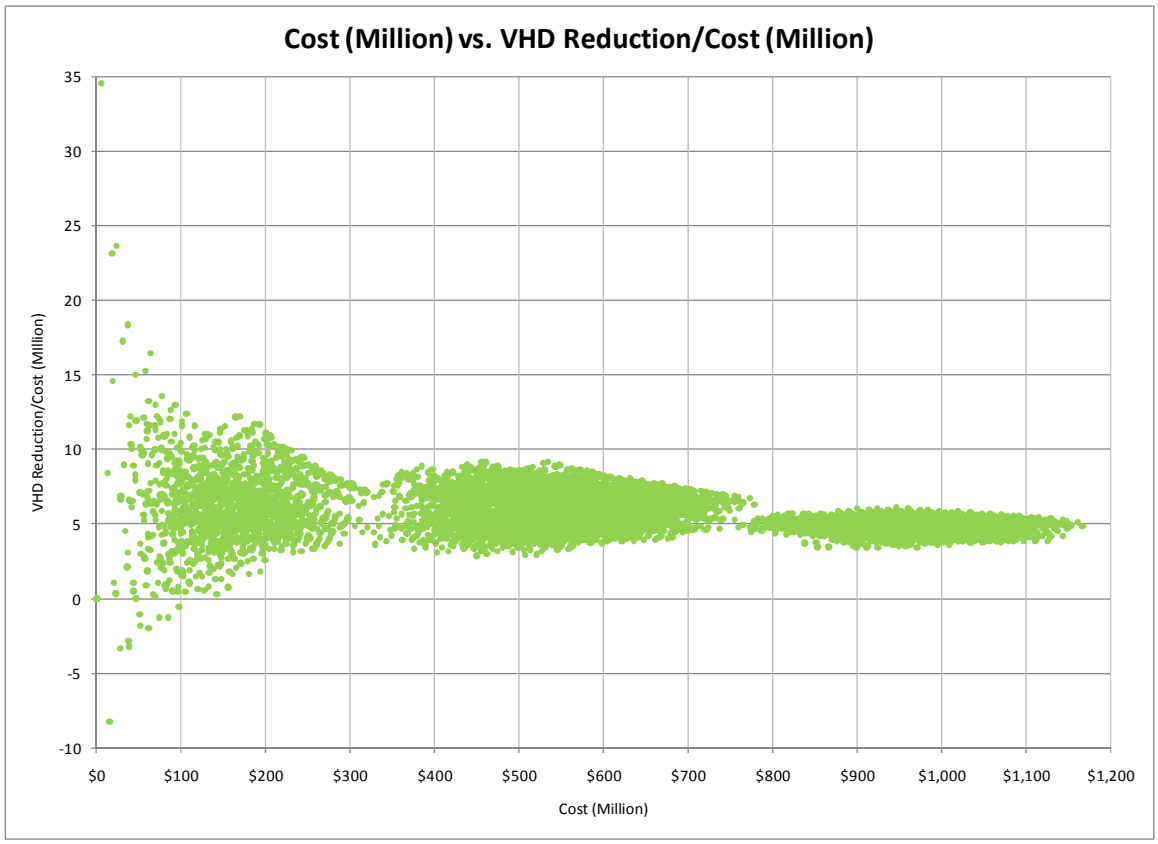
Figure 20. Cost (Million) vs. Projects



This provides additional proof that the specific combination of projects is important to scenario performance, particularly the resulting cost. A similar amount can be spent on different scenarios that construct one large project or multiple smaller projects. While the large project may yield the greatest reduction in VHD, the multiple smaller projects may still result in a substantial reduction in VHD while also addressing a host of secondary needs (local access, increased goods movement, etc).

Figure 21 compares scenario cost to VHD reduction/cost, which is essentially a measure of per dollar effectiveness (in terms of VHD reduction), for each additional dollar spent on a scenario. The general trend shows that the additional effectiveness of any dollar spent on a scenario converges around 5.0, as the total scenario cost increases. The real variation in VHD reduction/cost occurs between $0 and $300 million, which indicates some of the cheaper scenarios provide a greater VHD reduction/cost than more expensive scenarios. These scenarios primarily contain roadway widening projects, which are much less expensive than new freeway construction.

Figure 21. Cost (Million) vs. VHD Reduction/Cost (Million)

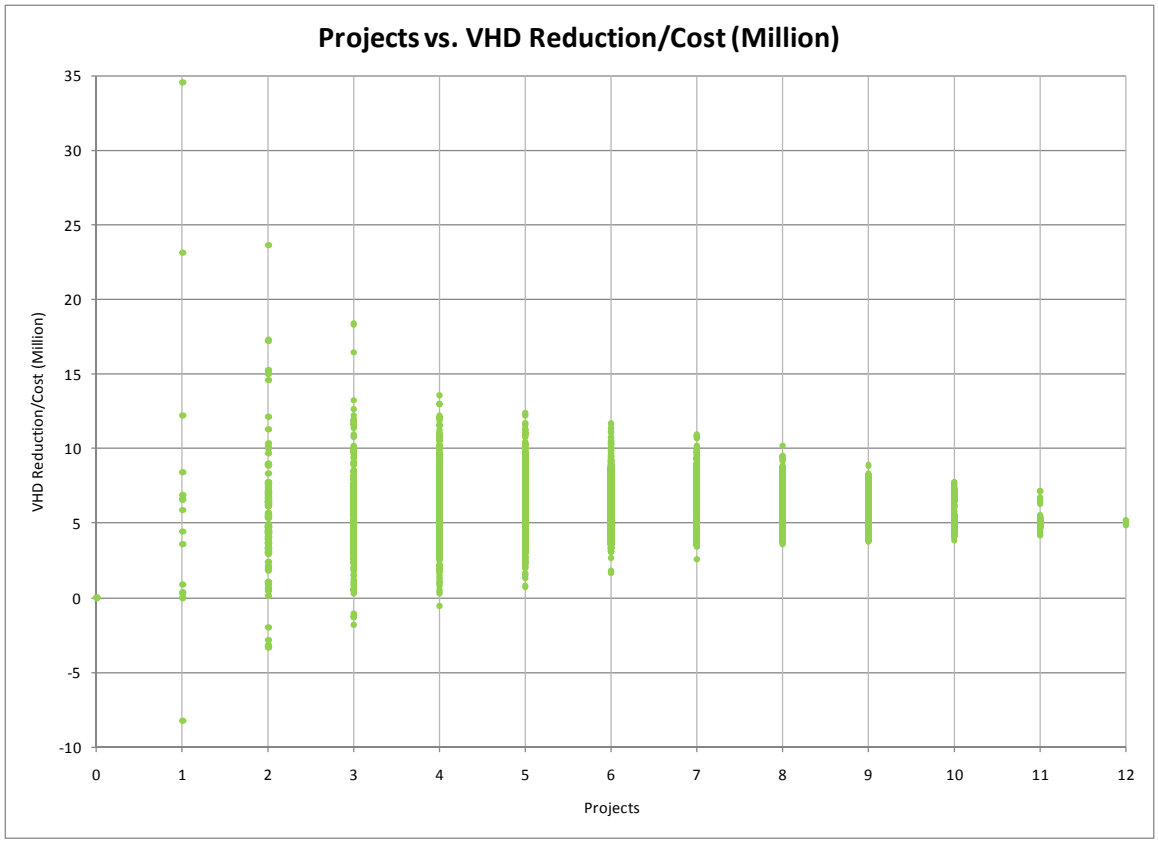


The general pattern in the figure shows that there are diminishing returns for each additional dollar spent on a given project scenario. Alternatively, there is greater VHD reduction/cost associated with the cheaper projects. This is important to acknowledge, due to the inherent risk associated with future activities, such as constructing roadway projects. In light of this, the future must be discounted because there is risk that some or all of the projects in a given scenario might not be built. History shows that money or other factors may limit the ultimate completion of all the projects.

Figure 22 compares the number of projects constructed to the corresponding VHD reduction/cost. The trend is similar to that of the previous figure, though this reveals that the top performing scenarios tend to have four or fewer projects. Additionally, the rate of return appears to flatten between seven and ten projects, and then decline further with eleven or twelve projects. Similar to the previous comments, the combination of projects

matters to the performance of a scenario. In this case, scenarios that contain more than seven projects do not provide additional VHD reduction in proportion to their additional cost.

Figure 22. Projects vs. VHD Reduction/Cost (Million)



6.4 Implementation Plan Strategies

As noted above, scenario performance is directly related to specific project combinations. While there is no prescribed method for determining the best sequence for building the projects under evaluation, there are three distinct implementation plan strategies for the PTIA area:

- Minimize cost
- Maximize VHD reduction
- Maximize VHD reduction/cost

Each strategy is viable and provides a valid basis for decision-making, though the timing and magnitude of VHD reduction and costs differ.

6.5 Minimize Cost Strategy

As shown in Table 6, this implementation plan focuses on building projects in order of increasing cost. This strategy calls for the construction of local road projects before any new freeway projects are built. This strategy is favorable from a financial standpoint, because it allows for the construction of six projects while spending less than $100 million. However, this strategy does not produce a 1,000 VHD reduction (roughly 18% of the maximum) until the seventh project.

Table 6. Minimize Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pleasant Ridge Road Widening	275	$ 18.8	14.6
3	Pleasant Ridge Road Relocation	153	$ 33.7	4.5
4	Pegg/Thatcher Street Connection	518	$ 51.6	10.0
5	Sandy Ridge Road Extension (North)	569	$ 74.3	7.7
6	Airport Connector	758	$ 97.4	7.8
7	Bryan Boulevard Loop	1,015	$ 135.2	7.5
8	I-40 Connector	1,472	$ 181.6	8.1
9	NC 68 Widening	1,559	$ 239.7	6.5
10	I-73 Connector	2,319	$ 316.5	7.3
11	I-73/I-74 Connector (Arterial)	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

6.6 Maximize VHD Reduction Strategy

As shown in Table 7, this implementation plan focuses on building projects in order of increasing VHD reduction. This strategy calls for the construction of new freeway projects before constructing any local road projects. This strategy is favorable from a traffic standpoint, because it produces a 3,059 VHD reduction (roughly 51% of the maximum) with the first project. However, this strategy frontloads the costs and surpasses $1,000 million with the construction of the seventh project. It should be noted that the "maximize VHD reduction" strategy project sequence is almost a mirror image of the "minimize cost" strategy.

Table 7. Maximize VHD Reduction Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	I-40 Widening	3,059	$ 444.1	6.9
2	I-73/I-74 Connector (Freeway)	3,602	$ 832.1	4.3
3	Airport Connector	4,296	$ 855.2	5.0
4	I-73 Connector	5,016	$ 932.1	5.4
5	I-40 Connector	5,406	$ 978.4	5.5
6	Pegg/Thatcher Street Connection	5,725	$ 996.3	5.7
7	Sandy Ridge Road Extension (North)	5,977	$ 1,019.0	5.9
8	Bryan Boulevard Loop	6,031	$ 1,056.8	5.7
9	NC 68 Widening	6,050	$ 1,114.9	5.4
10	Pleasant Ridge Road Relocation	6,078	$ 1,129.8	5.4
11	Pleasant Ridge Road Widening	6,060	$ 1,143.0	5.3
12	Sandy Ridge Road Widening	5,790	$ 1,148.6	5.0

6.7 Maximize VHD Reduction/Cost Strategy

As shown in Table 8, this implementation plan focuses on building projects in order of greatest incremental VHD reduction/cost, or the most effective projects per dollar spent. This strategy calls for the construction of local roadways before new freeway projects. This strategy is favorable from a VHD reduction/cost standpoint, because it produces a 1,250 VHD reduction (roughly 22% of the maximum) with the construction of the fifth project, for a cost of only $151.2 million. This strategy backloads the costs and requires an increment of $444.1 million between the tenth and eleventh projects. It should be noted that the "maximize VHD reduction/cost" strategy project sequence is very similar to the "minimize cost" strategy.

Table 8. Maximize VHD Reduction/Cost Strategy

Sequence	Project	Cumulative VHD Reduction	Cumulative Cost (Million)	VHD Reduction/Cost (Million)
1	Sandy Ridge Road Widening	192	$ 5.6	34.6
2	Pegg/Thatcher Street Connection	553	$ 23.4	23.6
3	Pleasant Ridge Road Widening	673	$ 36.7	18.3
4	Bryan Boulevard Loop	899	$ 74.4	12.1
5	I-73 Connector	1,250	$ 151.2	8.3
6	Pleasant Ridge Road Relocation	1,328	$ 166.1	8.0
7	Airport Connector	1,328	$ 189.2	7.0
8	I-40 Connector	2,209	$ 235.6	9.4
9	Sandy Ridge Road Extension (North)	2,299	$ 258.4	8.9
10	I-73/I-74 Connector (Arterial)	4,440	$ 573.2	7.7
11	NC 68 Widening	4,517	$ 631.3	7.2
12	I-40 Widening	5,575	$ 1,075.4	5.2

6.8 Comparison of Strategies

Figures 23 through 27 provide visual representations of the performance of the three implementation plan strategies. All three strategies perform well, especially when compared to the entire set of project combinations evaluated. While no single strategy clearly stands out as preferred, the "maximize VHD reduction/cost" strategy blends both the "minimize cost" and "maximize VHD reduction" strategies together.

Ultimately, this balance of VHD reduction and cost performance is a very reasonable strategy, and if pursued would be defendable from a cost standpoint, while also resulting in traffic improvements in the PTIA area. Additionally, the "maximize VHD reduction/cost" strategy is best for minimizing future risk. While all three strategies have similar VHD reduction at the end of the implementation plan (if all twelve projects are constructed and is considered a complete system), the "maximize VHD reduction/cost" strategy is a conservative approach that incrementally builds the best returning project out of all remaining available projects.

Since funding or other factors may halt ultimate completion of any implementation plan, the "maximize VHD reduction/cost" strategy provides interim systems that work – projects constructed in the early stages of the implementation plan are not dependent on the construction of other, future projects to realize the full value of earlier constructed projects. Therefore, a reasonable strategy is one that constructs a system that works well during all interim stages, since the ultimate completion of the implementation plan is an unknown variable that could be delayed, altered, or never fully realized.

Figure 23. Cost (Million) vs. VHD Reduction

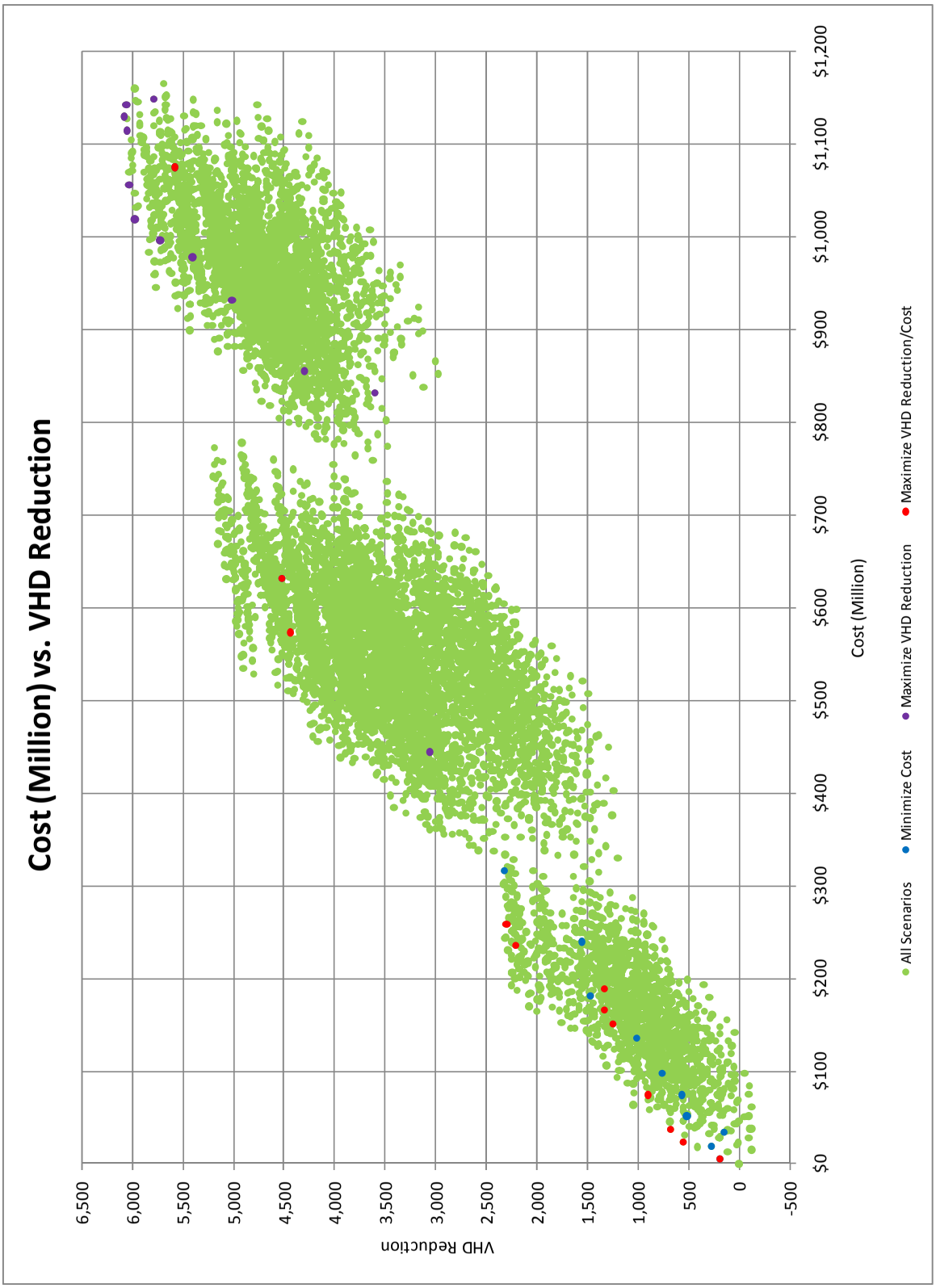


Figure 24. Projects vs. VHD Reduction

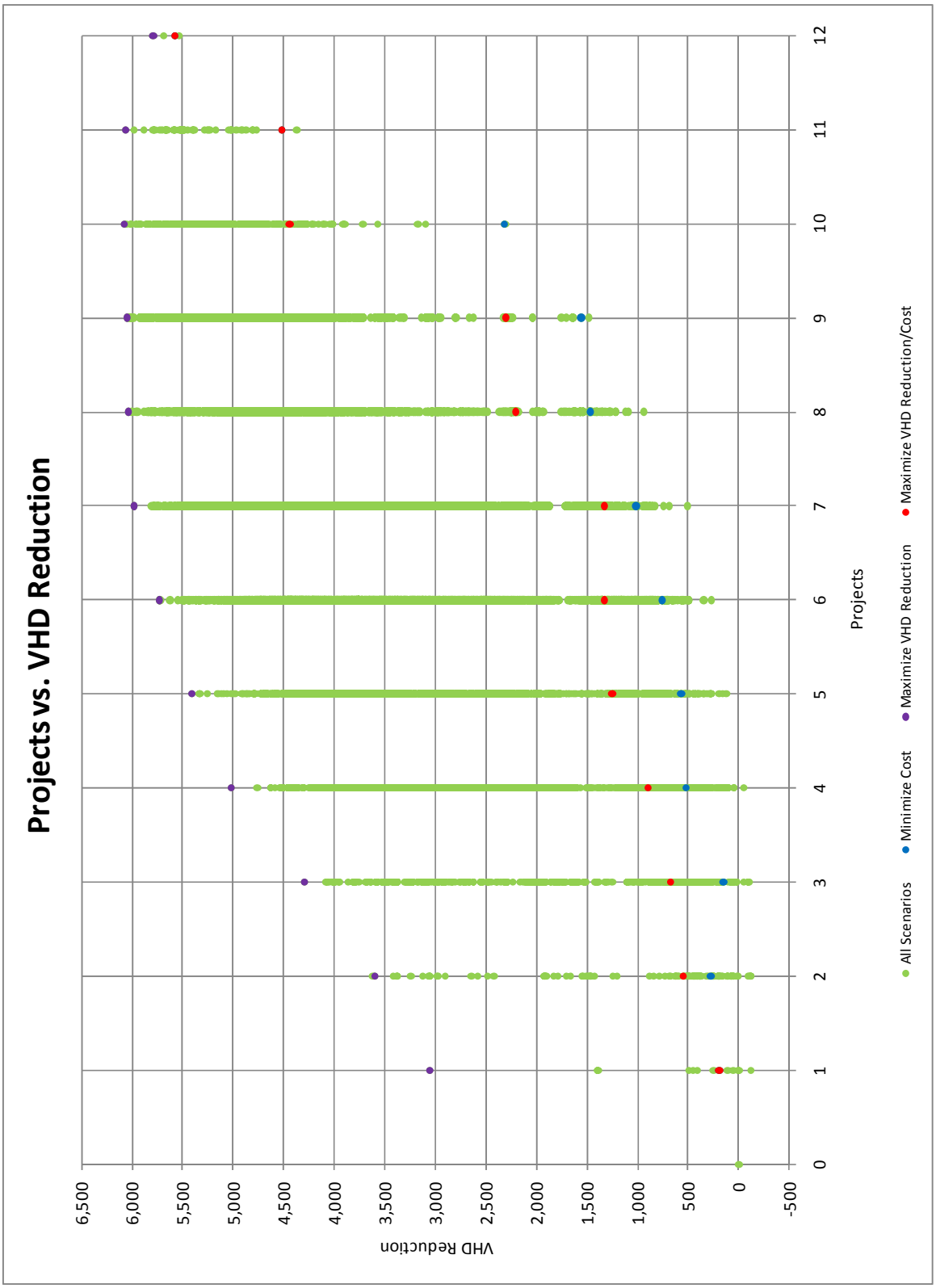


Figure 25. Cost (Million) vs. Projects

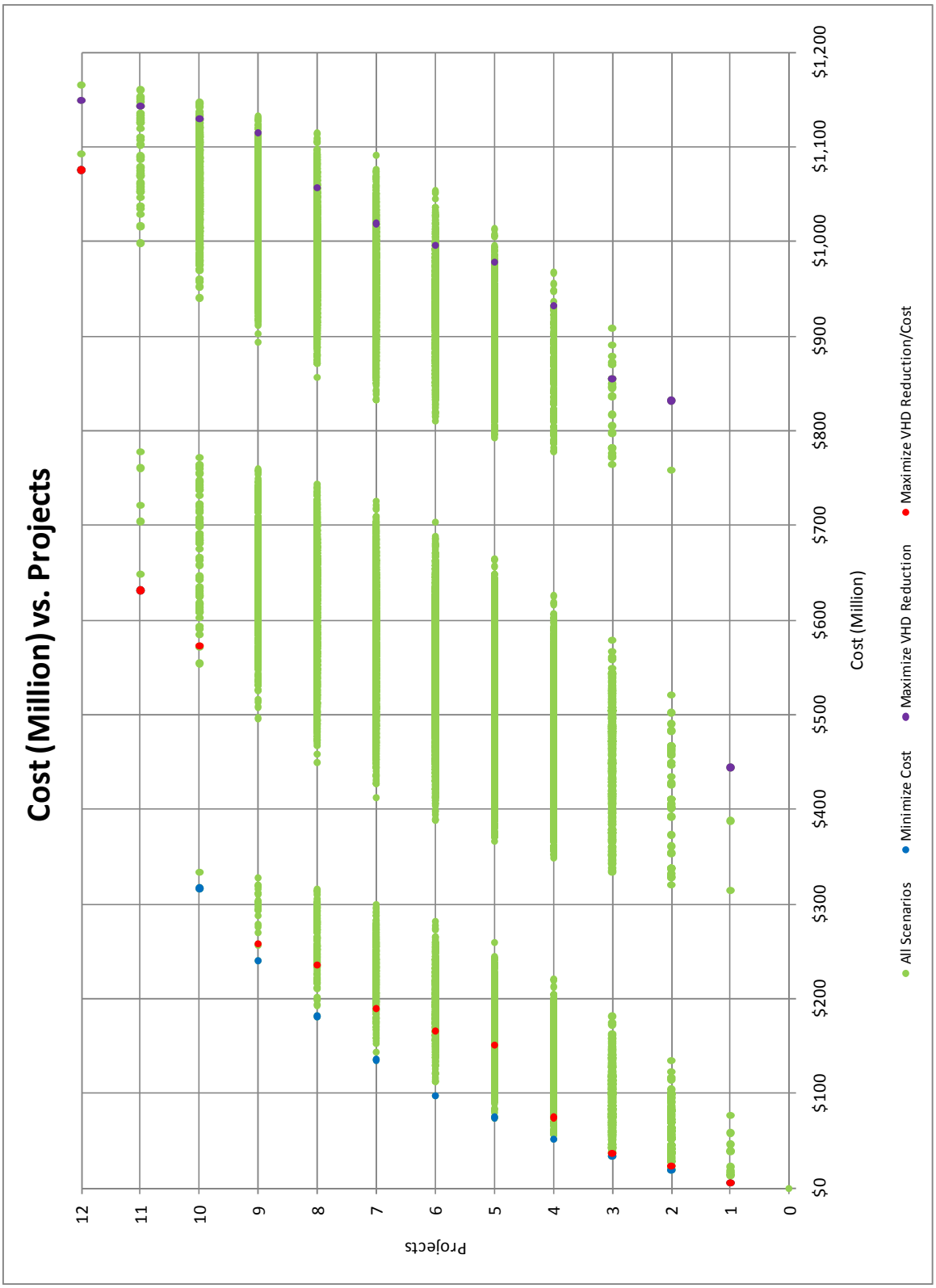


Figure 26. Cost (Million) vs. VHD Reduction/Cost (Million)

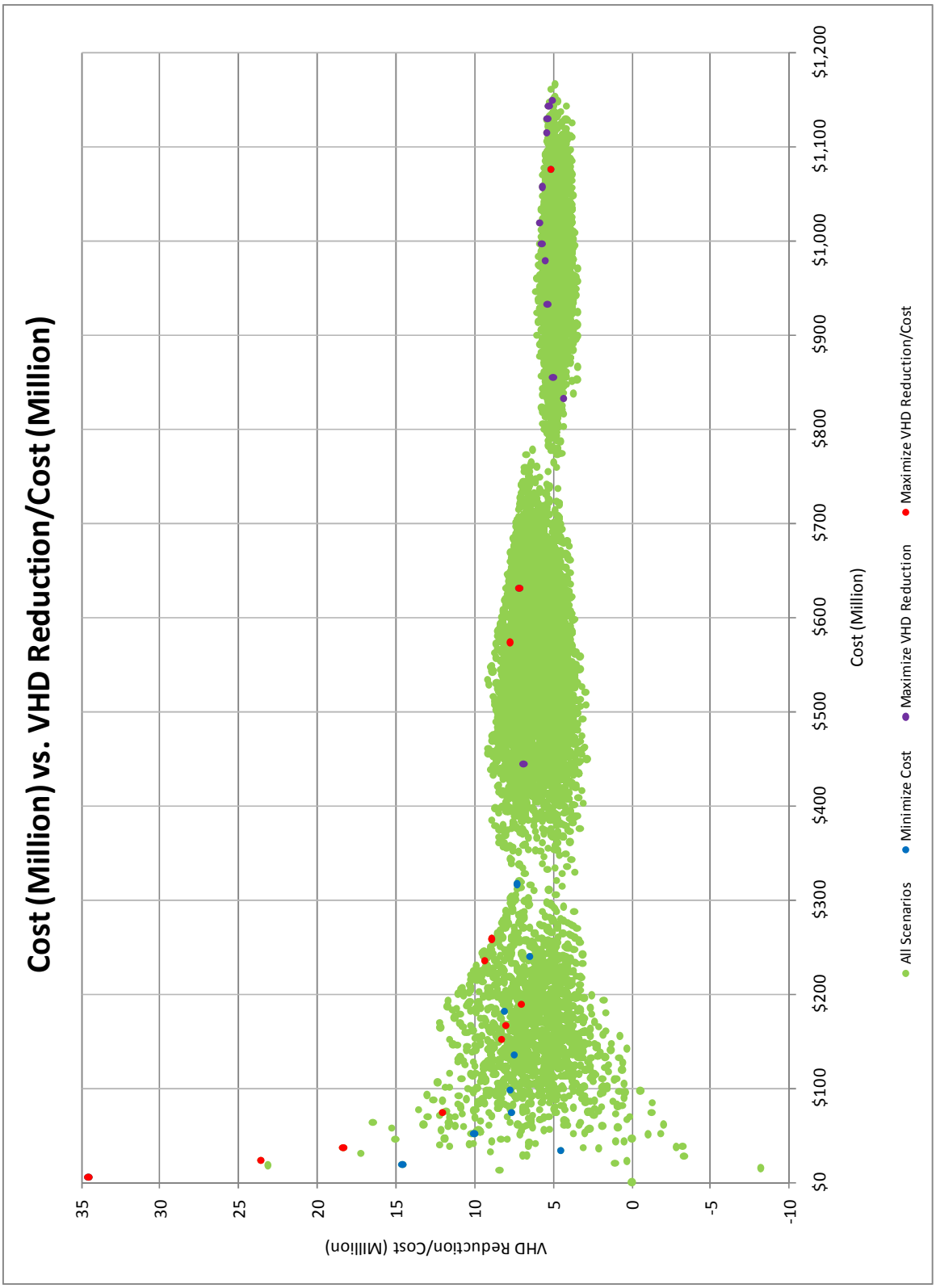
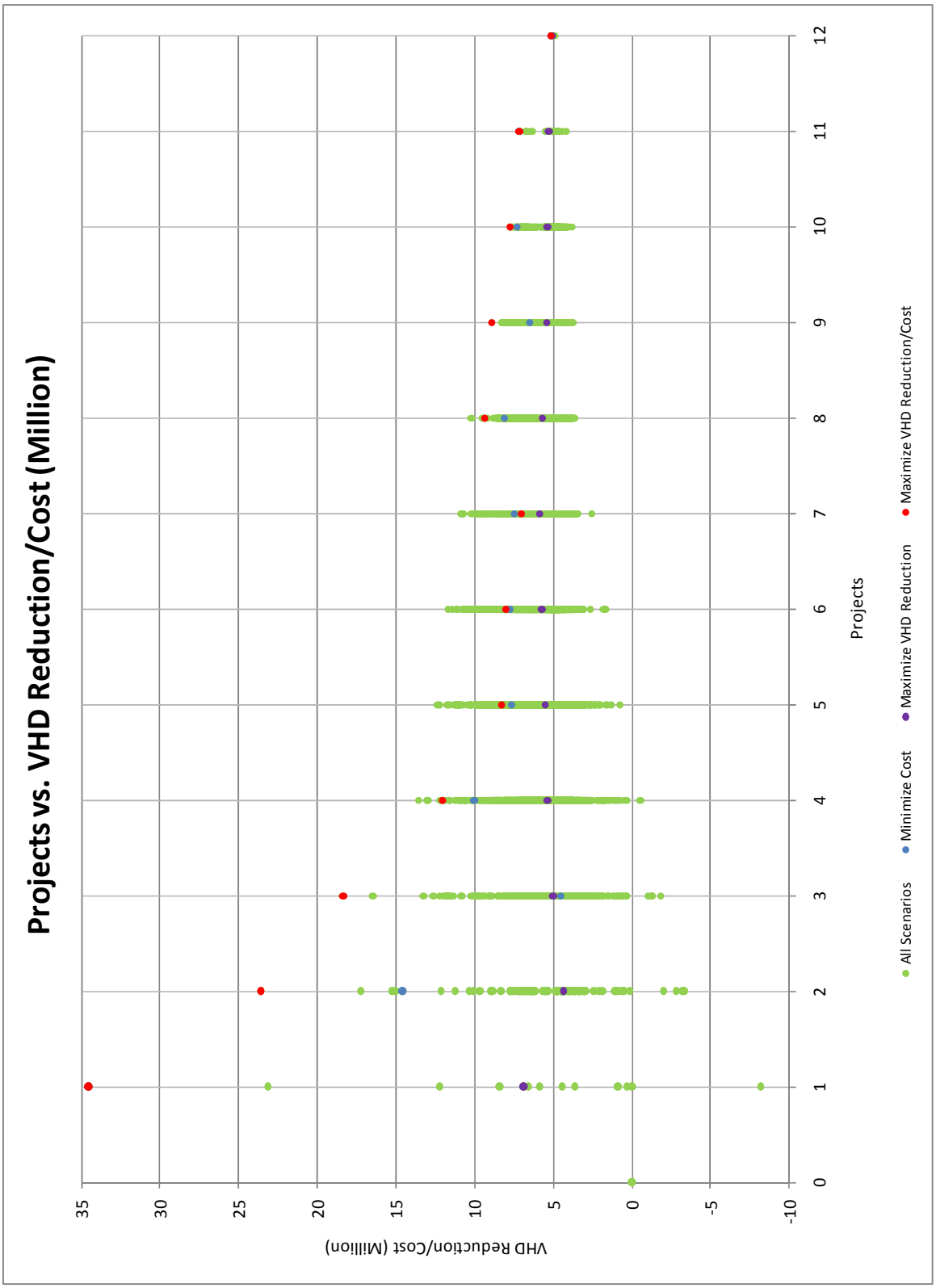


Figure 27. Projects vs. VHD Reduction/Cost (Million)



6.9 Notable Results

During the evaluation of the project scenarios and the implementation plan strategies, the following notable results became clear:

Sandy Ridge Road Widening

- Enhances Market Street widening project.
- Increases capacity parallel to I-40 by improving connectivity and access to alternate routes.
- Provides alternative access to the airport from the west and south.

Pegg/Thatcher Street Connection

- Driven primarily by land use development.
- Does not provide very equitable north-south capacity enhancements.

Sandy Ridge Road Extension

- East extension is not viable once I-73 Connector is built, due to loss of access to PTIA via Bryan Boulevard.
- North extension is viable only after the Airport Connector is built.
- A development driven collector extension could be beneficial, though no specific alternative was evaluated during the study.

NC 68 Widening

- Enhances Market Street widening project.
- Increases capacity parallel to I-73.
- Provides alternative access to the airport from the north, west, and south.

Pleasant Ridge Road Widening

- Enhances Market Street widening project.

- Reduces the need for a Sandy Ridge Road extension by providing a similar function when combined with widenings of Sandy Ridge Road and West Market Street.
- Provides alternative access to the airport from the west and south.
- Improves local access.

I-73 Connector

- Duplicates existing roadways that perform well today.
- Provides justification for Airport Connector.

Pleasant Ridge Relocation

- Warranted only after I-73 Connector and Airport Connector are built.
- Enhances local access.

I-73/74 Connector

- Arterial and Freeway options provide similar traffic benefits.
- Justified only after construction of the Airport Connector and/or Sandy Ridge Road Extension (North) and/or I-40 Connector.
- Will require additional improvements to local facilities serving the project.

I-40 Connector

- Traffic volumes and resulting benefits from this project are closely interrelated with other project decisions. The most significant interactions are associated with the widening of I-40, since these two projects share a substantial travel market. Combined with the Airport Connector and several road widening projects, the I-40 Connector could shift enough traffic off of I-40 to reduce or eliminate widen the segment between NC 68 and I-40 Bus. Conversely, if I-40 were to be widened, volumes on the I-40 Connector would be lower.

Airport Connector

- Arterial and Freeway options provide similar traffic benefits.

- Not justified until I-73/I-74 Connector, I-73 Connector, or I-40 Connector (or some combination) is built.

I-73 Connector Loop Roads

- Important for local access.
- Not justified until I-73 Connector and Airport Connector are built.

I-40 Widening

- Greatest benefit and greatest cost (as an individual project). However, some benefits in the study area (especially along I-40 between I-40 Bus and NC 68) can be obtained from other projects that shift traffic off of I-40. For example, building the I-40 Connector and the Airport Connector (combined with some other road widening) substantially lowers traffic on this portion of I-40, and could delay or eliminate the need for widening. On the other hand, completing the widening of I-40 could reduce the utility or demand for some of these (or other) projects.
- Difficult to construct while maintaining existing traffic patterns.

6.10 Other Considerations

The focus of this study involved the benchmarking and evaluation of project scenarios using traffic and cost information. While these two components are important factors influencing the selection and construction of roadway projects, they are by no means the only factors decision makers should consider. The following factors should be considered in concert with the results of this study:

- Local accessibility
- Changes in regional traffic patterns
- Goods movement
- Roadway network impact on development patterns
- Travel time changes to PTIA
- Enhancements to alternative modes